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LIVINGSTON STONE AND FISH CULTURE IN CALIFORNIA

By JOEL W. HEDGPETH [1]

When Livingston Stone came to California from New Hampshire in 1872 and established the first salmon hatchery on the Pacific Coast in the wild and unsettled McCloud River country of California, he could have had no idea that his site and much of the river itself would be far beneath the surface of one of the world's largest reservoirs 71 years later. Yet this will be the fate of Baird Hatchery when Shasta Dam is completed in 1943; not only will the site of the hatchery be under nearly 300 feet of water, but the remains of the faithful Indians who worked at the hatchery will be exhumed as well to be reinterred in some other "last" resting place. Of the hatchery itself there will be no memorial but the successful transplanting of chinook salmon to New Zealand and the entertaining but almost forgotten reports written by its founder to Professor Spencer Fullerton Baird, the first U. S. Commissioner of Fisheries. The magnificent salmon which brought Livingston Stone to California with the hope of establishing them in the East to replace the Atlantic salmon will no longer spawn in the McCloud by the foot of Mount Persephone, nor can they long be expected to survive, in any considerable numbers, the changes which will be wrought in their ancient domain by the development of the Central Valley Project. Yet long before this elaborate plan was considered possible, Livingston Stone foresaw the eventual extermination of the salmon in California by the "slow but inexorable march of the destroying agencies of human progress * * *. The helpless salmon's life is gripped between two forces—the murderous greed of the fisherman and the white man's advancing civilization * * *," he declared in an address before the American Fisheries Society in 1892, predicting the salmon's fate by asking a question that needed no answer, "* * * and what hope is there for the salmon in the end?" [2] That eleventh hour of which he spoke has lasted until the season of 1940, however, when some unaccountable train of circumstances has permitted a greater number of salmon to return to the rivers of central California than many can remember in the past 20 years. Perhaps it is appropriate that the salmon themselves should contribute this final irony to the long and for the most part futile struggle of the fish-culturists to maintain their numbers in the face of the ever increasing development of hydro-electric and irrigation projects. That this effort has failed and gives but little hope of future success is no reflection on the pioneer

[1] The writer was formerly employed by the U. S. Engineer Department, Sacramento, California, on the debris dams fisheries investigation and by the U. S. Bureau of Reclamation on the Shasta Dam salvage investigation. The opinions expressed in this paper are the author's own.

[2] A national salmon park. American Fisheries Society. Transactions, 1892, pp. 149-162, 1893. In this paper Stone advocated the establishment of a natural preserve on Afognak Island. The island was set aside shortly after this address by presidential proclamation as a forest and fish-cultural reserve, and in 1908 a hatchery was constructed.

work of Livingston Stone, for few men have worked with such indefatigable energy as did this former clergyman for the cause of fish culture and the dissemination of desirable fish to other parts of the country. It is on the doorsteps of those who have forgotten or who ignore the experiences and efforts of such men as Seth Green, Charles G. Atkins and Livingston Stone that we must lay the blame for the fact that fish culture has not progressed as far as it should.

Acknowledgments

The author wishes to express his obligation and gratitude to Mrs. Edmund Cushing Stone for much information about her late father-in-law and for the generous loan of material and photographs. Other sources for this paper are the annual reports of the U. S. Commissioner of Fisheries from 1872 on, especially those volumes in which Stone's reports of operations at Baird appeared, and numerous scattered papers. Mr. Don Bloch of the informational service of the U. S. Fish and Wildlife Service and Miss Ruth G. Buffum, Librarian of the Meadville Theological School have kindly consulted records for the writer and their letters have supplied important details. A sketch of Stone's life and genealogy, with a photograph taken in later life, appeared in the first volume of R. A. Oakes' "Genealogical and family history of the County of Jefferson, New York," pp. 626-633 (New York and Chicago, Lewis Publishing Co., 1905. 2 vols.), and his fisheries papers are listed in Bashford Dean's "Bibliography of Fishes." Sources directly quoted in this paper have been indicated by footnotes.

I

Livingston Stone, the founder of Baird Hatchery and one of the pioneers of the Federal fish-cultural program, was born on October 21, 1836, in Cambridge, Massachusetts. He was descended by direct lines from the earliest settlers of Plymouth Colony, for his father's people arrived in the new world in 1636, and his mother was a Winship, of one of the oldest families of New England. Little has been recorded of his boyhood except his excellent record in the public schools of Cambridge, and of his career at Harvard not much more is known except that he studied Latin, Greek and mathematics, and was graduated with honors in 1857. Although his health had been delicate since childhood, he had learned to box and play tennis and was fond of outdoor excursions, but he seems to have attained his greatest proficiency at chess. In his later years he was noted as an excellent player, capable of defeating half a dozen opponents in a simultaneous match while blindfolded. It is not surprising that he should have decided to enter the ministry since he came from a staunch Unitarian family, and after completing his course at Harvard he entered the Meadville Theological School, from which he was graduated in 1860. Evidently his poor health prevented him from serving as a chaplain in the Civil War, since he was posted on the list of "Candidates for Settlement" shortly after his graduation and until his ordination as pastor of the Charlestown, New Hampshire, church on June 1, 1864. During the year 1862, he was in charge of the Unitarian Church in Billerica, Massachusetts, and toward the end of 1863, accepted the

invitation from Charlestown, which resulted in his being called to the pulpit of that church in the following year.

Although Stone was well liked by his congregation and seemed destined for at least a modest success as a clergyman, his health did not improve and he decided to retire from the ministry in favor of an occupation which would enable him to be out of doors. Accordingly, he resigned his pastorate in 1866, despite the pleas of his parishioners to remain, and established his Cold Springs Trout Ponds at Charlestown. His decision to take up fish culture had apparently been reached as a result of a preliminary experiment in hatching trout eggs. Whether this experiment was a natural result of his canoeing and fishing excursions in Maine and New Brunswick waters or the consequence of a meeting with some early fish-culturists, Stone does not say in his reminiscences. As his friendship with Seth Green began about this time, it does not seem unlikely that Green's example had some influence on Stone's selection of a new profession.

When Livingston Stone established his hatchery in 1866, fish culture was in its infancy in North America, and the very idea that fish could be artificially hatched was a novelty. The newspapers made much of the new fad and Stone found himself on the ground floor of a growing business. He became the editor of a fish-culturist's column for a New York paper and soon established himself as an authority on the subject. "Those were the palmy days of trout breeding in this country," he wrote many years later.[3] And, indeed they were, with eggs selling for $10 a thousand and fry for $40 a thousand. Among other items sold by Stone's hatchery in its early days was a complete outfit of one hundred fish and a trough for the parlor, suggested in a circular as a "novel Christmas present."

Stone was not content to work with trout alone, and in 1867 he was among the first to attempt the artificial propagation of salmon in the United States. These early experiments were carried out with eggs collected from salmon speared in New Brunswick by W. W. Fletcher. A salmon hatchery had already been started on a small scale by Samuel Wilmot at Newcastle, Ontario, but the exorbitant price of $40 a thousand demanded for eggs by the Canadians was too much for the new State fish commissions, and in 1868 Stone was sent to New Brunswick in a cooperative venture by the State commissions of New Hampshire and Massachusetts to establish a salmon hatchery, under an arrangement by which half of the eggs were to go to the Canadians. This hatchery, the first large scale establishment of its kind in North America, was on the Miramichi River. The eggs for New Hampshire and Massachusetts were brought back by Stone to his Charlestown hatchery, but the Canadian share was neglected by the man left in charge and after two seasons the project was abandoned.

By 1870, fish culture was an established profession and a need for an association or society was recognized by those engaged in it. The idea for a sort of trade association to fix prices and discuss hatchery procedure seems to have occurred first to Rev. William Clift, but it is not difficult to imagine that most of the actual work of getting the group together was done by Livingston Stone. At any rate, in 1870,

[3] Some brief reminiscences of the early days of fish-culture in the United States. U. S. Fish Commission. Bulletin, vol. 17 (1897), pp. 337-343, 1898.

Clift, A. S. Collins, J. H. Slack, Fred Mather and Stone met to organize the American Fish Culturists' Association. Clift was the first president of this new society, now known as the American Fisheries Society, and Livingston Stone was the first secretary, and one of the drafters of the constitution. During the first year Stone wrote over 500 letters, including one to Louis Agassiz which began an enduring friendship, and on February 8, 1872, the society held its first annual meeting. At this meeting the need for a policy broader than that of price fixing and exchanging trade secrets was recognized and accordingly the name was changed to the American Fisheries Association (later to Society) to symbolize its broader policies, and the federal government was petitioned to establish salmon hatcheries on both Pacific and Atlantic coasts and to undertake a general fish-cultural program.[4] The young association evidently had an influential champion in Congress in the person of Hon. Robert B. Roosevelt, an ardent angler and amateur fish-culturist, for by June, 1872, an appropriation of $15,000 was made by Congress for the propagation of food fishes, with the details of the program left up to Commissioner Baird. Baird promptly called a meeting of the state commissions and members of the American Fisheries Association to recommend the disposition of these funds. At this meeting, held on June 13, 1872, it was agreed to assign a third of the funds to planting shad in the Mississippi, and Seth Green and William Clift were selected for this task; another third was to subsidize Charles G. Atkins' salmon hatchery (built in 1870) on the Penobscot River in Maine; and the remaining third of the funds was to be used in establishing the groundwork for the collection of eggs of the Pacific salmon to be introduced in eastern waters to compensate for the depletion of the Atlantic salmon. As Livingston Stone was an active participant in this meeting and the idea of bringing eggs from the Pacific coast was his, he was delegated to carry out this last phase of the program. Accordingly, after a series of conferences with Baird, he was officially notified of his appointment as a Deputy Fish Commissioner by a letter dated July 6, 1872.

Livingston Stone, at the time of his departure for California, must have been a striking figure with his magnificent russet brown Dundrearies in their prime, although he was of a medium, stocky build. The threat of ill health that had driven him from the ministry must have lost some of its force or he could scarcely have considered a trip to California in the days when railroad travel was not without its vicissitudes, as he was to discover a year later at the peril of his life. He had planned to expand his hatchery at Charlestown, acquiring for

[4] A somewhat different version of the founding of the Society is given by Mather in his book on fish culture (F. Mather, "Modern fish culture in fresh and salt water," Field and Stream Publishing Co., 1900). According to his account, "Mr. A. S. Collins, Dr. J. H. Slack and myself called a meeting" which resulted in the organization of the American Fisheries Society. Finding that this did not help to sell their eggs any better, they passed resolutions for government action. Mather evidently believes that he was also responsible for the establishment of the U. S. Fish Commission, to judge from his discussion, which is not phrased in the most modest or self-effacing terms. He ignores the existence of Stone (still active when this book was written) except to point out that he knew more about packing salmon eggs for shipment than Stone did and that his discovery of the method of lining hatchery troughs with tar superseded Stone's charcoal method. Ward T. Bower's version of the history of the American Fisheries Society (American Fisheries Society. Transactions, 1910, pp. 323-369), although based on Stone's account ("The origin of the American Fisheries Society," *Ibid.*, 1898, pp. 56-64), is the most objective account that has been published and is free from the personal bias evident in Mather's account.

that purpose considerable areas of land which he was to advertise for sale many years later in a series of amusing broadsides, and had just completed his book on trout culture, "Domesticated Trout," which was to go through several editions and become one of the standard manuals of fish culture. Although he kept his Cold Springs hatchery for several years after his appointment as Deputy Commissioner, his life for the next 30 years was to center around the hatchery on the McCloud River, which he named Baird in honor of his friend and employer. The Cold Springs hatchery is now operated by the New Hampshire Fish and Game Department.

II

Livingston Stone lost little time in starting on his mission after receiving his official authorization of July 6, 1872. On August 1 he left Boston for California, had found a hatchery site on the McCloud River by September 1, and on December 9 he was in San Francisco writing his report of the first season of his pioneering adventure in fish culture. This brief chronology gives little idea of the almost desperate dashing from place to place to find a hatchery site during those first weeks in California nor of the actual work accomplished.

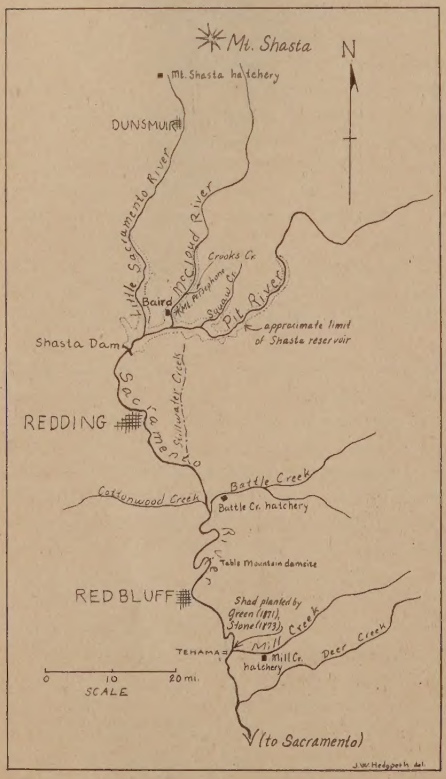

FIG. 31. Map of the upper Sacramento River System, showing the location of Baird, Mill Creek, Battle Creek and Mt. Shasta (formerly Sisson) hatcheries.

On arriving in California, Stone discovered that little was known about the habits and spawning grounds of the salmon, and that even the California Fish Commissioners had only the vaguest ideas on the subject. Their first suggestion was that he establish himself at Rio Vista, a few miles below Sacramento, where the salmon were presumed to spawn. He needed only a glance at this broad sluggish reach of the river to realize that it would be necessary to search much farther upstream for the spawning grounds of the salmon. After a few other false leads he met the chief engineer of the Pacific Railroad, who mentioned having seen Indians spearing salmon on the McCloud River. Following this lead, Stone journeyed north to Red Bluff, then the railroad terminus, and thence by stage to the Pit River ferry.

From there he walked up the river bank to the McCloud and two miles up that stream to the ancient Indian campsite and fishing grounds.

It was a spectacular scene. On the far side of the river the forest grew down to the very water's edge and behind the dark trees the grey limestone crags of Mount Persephone loomed like a tremendous bastion. On the near side, the river, after turning around the base of a little knoll on which the Indians buried their dead, ran quietly by a sand-bottomed cove. Here the Indians waded out to the white water of the rapids to spear the salmon as they cleared the shallow bar, and behind the cove was the camp ground, a shoulder of a hill, pitted by the fire holes of countless generations. Even today arrowheads can be found in the blackened earth among the heat-shattered river stones.

When Livingston Stone first saw this scene on August 30, 1872, the season was already far gone and he and his two young assistants, Myron Green and Willard T. Perrin (his nephew), set to work without delay. They had hoped to enlist the aid of the Indians but found that few of them knew any English, and being unable to communicate with them they had to build the station by themselves. In 15 days they had built a house and hatchery apparatus, including tanks and flume, and were ready to begin collecting eggs, although they were over 50 miles from the nearest railroad and sawmill and had to work during a hot spell with the mercury wavering from 105° to 112° in the shade during the fortnight. On September 16, they began to capture the salmon but found that they were too late for the best part of the run. They managed to gather 50,000 eggs, however, and 30,000 of these survived to be shipped East on October 23. Of these first 30,000 eggs, all but 7,000 had to be discarded on arrival. Although the record is somewhat vague on the point, between two and three hundred of these eggs appear to have been reared to fingerling size and planted in the Susquehannah River in March, 1873.

Lover of the out of doors that he was, Stone could not help but be impressed by the almost virgin wilderness in which he had established the hatchery, and in his reports are many fine descriptions which would never reach print were they submitted to those who edit today's carefully dehydrated government reports. Especially memorable is his description of a night during the first season in 1872, on the McCloud River: "On the darkest nights the scene on the river bank was exceedingly wild and picturesque. Behind us was the tall, deep shadow of Persephone Mountain, and before us at our feet ran the gleaming, rapid current of the McCloud, while the campfire threw an unsteady light upon the forest, mountain and river, suddenly cut off by the dense darkness beyond. The flaming pitch pine torches, stuck into the sandy beach at intervals of 20 feet, to guide the boatmen, the dusky forms of a half dozen Indians coiled around the fire, or stoically watching the fishing, the net, the fishing-boat, and the struggling fish, added to the effect, and made a picture which, especially when the woods were set afire to attract the fish, was one of surpassing interest. It was quite impressive, in the midst of these surroundings, to reflect that we were beyond the white man's boundary, in the home of the Indians, where the bear, the panther, the deer, and the Indians had lived for centuries undisturbed."[5]

[5] U. S. Fish Commission. Report, 1872-73, pp. 172-173. This is the first mention of Persephone; perhaps the name was given by Stone himself.

There is no trace of sermonizing in these long reports, however, nor is there any other evidence that he carried his former profession with him, although the absence of oaths and cards at the hatchery did cause a reporter to marvel when he visited the hatchery in 1874. While he was always interested in Sunday services for the Indians at Baird and perhaps participated in them to some extent, he had evidently given up preaching entirely, renouncing all the privileges and prerogatives of a minister. On at least one occasion he preached at his former pulpit in Charlestown, however, coming to the rescue of a pastor taken suddenly ill. Perhaps he thought it unseemly, being a serious minded man, to mix his former profession with his present one, but it seems more likely that fish culture was his greater love. Although he was occasionally referred to with the title of Reverend by some of his colleagues, he preferred to forget the title and in later years dropped it altogether. When he did use a title, it was the

FIG. 32. The founders of Baird: Myron Green, Livingston Stone and Willard T. Perrin. (Photograph taken in San Francisco in 1873.)

honorary A.M. granted by his alma mater in recognition of his services to fish culture.

Not only did he succeed in describing the widerness about him in vivid language, but he also recorded something of the customs of the Indians, and in his first reports, devoted several pages to a vocabulary of their language, certainly an unexpected detail to be included in a report of fish-cultural operations. But all this did not seem to be enough to keep him busy, for he found time to look over the country between Mount Shasta and San Francisco. In those days when rough narrow wagon roads were the only highways, this must have been a rather strenuous pastime, but he mentions it only in a brief paragraph in his report: "Permit me to add that during the fall, I traveled the whole length of the Sacramento River, from its sources around Mount Shasta to its outlet at the bay of San Francisco, and also ascended the McCloud River as far as it is accessible, which is about 20 miles * * *."[6]

[6] U. S. Fish Commission. Report, 1872-73, p. 175.

Livingston Stone's second season in California, that of 1873, was even busier than his first. In January he was still in San Francisco, preparing to receive a shipment of whitefish eggs from the Great Lakes. He had been given short notice of this shipment and was obliged to scurry around for a suitable lake in which to plant the fish. He selected Clear Lake after satisfying himself that it appeared suitable for fish life since there were already several varieties of fish, some of them in abundance, in the lake. The spawning migrations in the small brooks tributary to the lake were so heavy for example, that it was "difficult to cross the fords with a horse * * *" because of the almost solid mass of fish running.[7] The whitefish eggs arrived safely and were hatched in an improvised establishment at Kelsey's Mill near Kelseyville and the fry planted in the lake. Although a few fish were taken for a year or two after this experiment, the attempt was unsuccessful, as were all the later attempts to plant the whitefish in other California lakes.

The arrangements for hatching the whitefish eggs had hardly been completed when Stone was summoned East to bring out an aquarium car—a fruit car improvised for the purpose—with a load of approximately 300,000 assorted fish, including catfish, eels, bullheads, perch, bass, trout and lobsters. After numerous delays, sidetrackings and a continuous struggle for ice between New Hampshire and Chicago, Livingston Stone, Myron Green and Willard T. Perrin were finally on their way west from Chicago, destined to meet with a disaster which nearly cost them their lives. They had reached Omaha safely and were beginning to believe that they would be able to get the fish to California safely when the bridge over the Elkhorn River gave way and threw part of the train, including the fish car, into the river. One man was crushed to death in the cab and two swept down the river in a "drowning condition." Stone and his assistants managed to work free of the car in which they were trapped by the shifting fish tanks and swim to safety.

The worthy Fish Commissioners of California, Messrs. Throckmorton, Redding and Farwell, were determined to have fish brought to California, and Stone had hardly finished telegraphing the news to Professor Baird of the inadvertent planting of the fish in the Elkhorn River before he was ordered to return East and take a shipment of shad to California.[8] This venture proved more successful and the transportation across the continent proceeded without mishap although with a continuous struggle to keep the fish cool during the first part of the trip and warm over the Rockies. It was considered necessary to change the water every two hours, and there were several lively arguments between the engineers and train crews on one side and the fish culturists on the other. Of the 40,000 shad brought from the Hudson River on this trip, 5,000 were planted in the Jordan River in Utah, and 35,000 in the Sacramento River at Tehama on July 2, 1873, with a loss of but 400 fish on the long trip. This was the second planting of shad in Cali-

[7] U. S. Fish Commission. Report, 1873-74 and 1874-75, p. 378.

[8] That Professor Baird did not believe the fish a total loss is evident from his report for 1872-73, in which he remarks that "some of (the fish) will be valuable acquisitions to the systems of water where fate has consigned them." U. S. Fish Commission. Report, 1872-73, p. xxix.

fornia, the first planting having been accomplished two years before by Seth Green.[9]

Having seen the shad safely into the river, Stone and his two assistants left for the McCloud River to begin the second season of egg taking. They arrived the next day to find the Indians resentful over this usurpation of their traditional fishing grounds, and it was not until they understood that the fish were to be turned over to them after the eggs had been taken that they became reconciled to the new order of things. There must have been other tense moments during this season, and we find Stone writing in his report that the "Indians had until this time succeeded in keeping the white man from their river, with the exception of a Mr. Crooks, whom they murdered a week after I arrived." Although Stone himself seemed to have a way with the Indians and became their lifelong friend, there was Indian trouble of some kind or another for several years in the vicinity. Most of the trouble was more imagined than actual, although it must have been a trying day for Loren Green (Myron's elder brother) in 1879, when he was obliged to stare a group of Indians in the eye while they fingered their knives and waited for him to make the first move, on the very scene of the demise of the Mr. Crooks mentioned above. Fortunately for Green, the Indians, after several tense hours, took themselves off without acting on their threat.

The second season on the McCloud was also noteworthy for the construction of a water wheel to supply the hatchery troughs (as in the first season, the troughs were under a large tent). This effort was watched with the "greatest solicitude," and when the wheel was completed the occasion was celebrated by raising a large flag at sunset. But the wheel failed to work as expected and there was great gloom in the camp when the wheel stopped after an abortive groan. With the removal of half the buckets, however, the wheel operated successfully and for several years a wheel of some kind or another was the main source for the hatchery water supply. While most of the eggs from the season of 1873 were shipped East in the effort to replace the Atlantic salmon, a half million fry were returned to the McCloud River and 20,000 eggs were shipped to New Zealand. This was the first of many shipments of eggs which eventually resulted in the establishment of the chinook salmon in New Zealand waters, which must be considered one of the happier examples of fish introduction.[10]

The first two seasons on the McCloud were experimental in character, but with the season of 1874 operations on a large scale were begun in earnest and 5,752,000 eggs were taken. In that year a crew of nine, including a photographer and a Chinese cook, was engaged and an extensive building program was carried out. Dwelling houses, sheds and a rack in the river were constructed, but it was not until 1876 that a permanent hatchery building was erected. The hatchery was now becoming famous and began to attract visitors, among them a roving

[9] For a detailed account of the various introductions of fish to California, see Hugh M. Smith, "A review of the history and results of the attempts to acclimatize fish and other animals in the Pacific States." U. S. Fish Commission. Bulletin, vol. 15 (1895), pp. 379-472, pls. 73-83, 1896.

[10] Introductions before 1900 were failures, according to F. A. Davidson and S. J. Hutchinson, "The geographic distribution and environmental limitations of the Pacific salmon (genus *Oncorhynchus*). U. S. Bureau of Fisheries. Bulletin, vol. 48 (1938), pp. 667-692.

journalist who contributed a full page article to the "Sacramento Record," in which he made much of the energy of the crew and their willingness to sleep on rough planks, and was evidently impressed by Livingston Stone's polished Harvard manner, for he came away with the opinion that the workers had proved that "cultured intelligence and horny hands may meet in harmony."[11] A more formal article appeared in the "Overland Monthly" for January, 1875, overburdened with the mellifluous language of the day but revealing that from a thousand eggs taken by the hatchery 950 fish could be expected. That nature could do better was inconceivable, is at least the implication of this article, which in one passage describes salmon eggs as "amber colored spawn globules."[12]

Another visitor in 1874 was John Muir, walking from Redding to Mount Shasta, a trip which was described in his "Steep Trails," although he did not mention his stay at the hatchery in the book. For several days he remained at the hatchery, observing the Indians and trying to persuade Stone to accompany him on his trip to Mount Shasta. John Muir, who could never leave a hill unclimbed, and Livingston Stone, always eager for such an excursion, climbed Mount Persephone on October 19. They ran most of the way down the hill, and Stone earned Muir's admiration for his running ability. Unfortunately, Stone could not spare the time to go to Mount Shasta after all, so John Muir went on alone, after writing a brief description of the hatchery which appeared in the "San Francisco Bulletin" for October 29, 1874.[13]

With a large crew the work was easier than it had been during the first two seasons and Sunday became a day of rest and recreation. It was on one of these quiet Sundays that Stone and some of his young assistants explored the caves in the limestone crags of Mount Persephone across the river from the hatchery. This excursion is described in such vivid detail that it might well be published in a guide book for the Shasta reservoir area, for a trip by boat from Shasta Dam up the McCloud River to the Baird caves (famous among paleontologists for the Pleistocene fossils found in them) may become one of the scenic attractions of the region when Shasta Dam is completed. Reprinting this original description of the caves would go far toward correcting a curious mistake in a recent guide book.[14]

It was in this year, 1874, that Stone brought out the second assortment of fish in an aquarium car to make up for the accident in Nebraska the year before. This shipment included black bass, glass-eyed perch, catfish, Atlantic salmon, eels, lobsters, and some unidentified catfish taken on at a stopover at the Elkhorn River. The California Fish Commission had also asked for striped bass, but their suggestion came too late for the proper preparations to be made and these fish were not

[11] Salmonidae. Pisciculture, etc. Sacramento Daily Record, August 29, 1874, p. 8.

[12] Turner, W. M. Salmon hatching on the McCloud River. Overland Monthly, vol. 14, pp. 79-85, 1875.

[13] From John Muir's journal. The writer wishes to thank Mrs. Linnie Marsh Wolfe for her courtesy in showing him Muir's journal and scrapbook.

[14] "California, a guide to the Golden State" (American guide series), New York, Hastings House, 1939, 713 pp. The note on page 436 under Baird reads: "Left from Baird on a dirt road 0.2 mi. to the United States Fish Hatchery where salmon are propagated in the California Caves on the bank of the river." Stone's description will be found in U. S. Fish Commission Report, 1873-75, pp. 462-464.

brought out until 1879. Most of the fish brought out on this trip did not establish themselves, but the plantings of black bass and horned pouts *(Ameiurus nebulosus)*, together with successive plantings, were successful, and now these fish are major elements of the fauna of California waters. "To Mr. Stone more than to any other person is the direct credit due for the introduction of most of those fishes which have since attained economic importance," wrote Smith in his report on the acclimatization of fish in the Pacific States,[15] and according to Stone himself it was no mean feat to bring a car load of fish across the country in the days when railroad schedules were not too reliable and suitable water often unavailable for hundreds of miles. The 1874 trip lasted eight days and was evidently uncomfortable: "The unusual chill and dampness that pervaded the car, together with the immense labor and loss of sleep, had made nearly all on board sick, for a greater or less time; and altogether the trip had been one of such extreme hardship and severe labor, that we hailed the last day with a sense of greatest relief."[16]

Stone did not conduct another such wholesale experiment in fish introduction until 1879 when he brought out 150 striped bass, which he released at Martinez, along with a consignment of lobsters, eels and black bass. The striped bass established themselves with remarkable success from this insignificant number and the second planting by J. G. Woodbury in 1882 was more or less of an anticlimax. Twenty-one of the original twenty-two berried lobsters survived the trip and were planted off Bonito Light, never to be heard of again.

By 1875, the hatchery on the McCloud River was well established and placed on a year-round basis under the charge of Myron Green during the time when Stone was away. On December 9, 1875, the hatchery and its environs were set aside as a government reservation by a presidential proclamation, although it was not known as Baird until the establishment of a post office in 1878. During the season of 1875, when there was a notably large salmon run in California, Stone was delegated to investigate the declining salmon fishery of the Columbia. Two years later he founded the Clackamas Hatchery near Portland, partially as a result of this investigation. The season on the McCloud River was not without its diversions, however, principally on account of one Leschinsky who believed that his use of the fishing ground near the hatchery had given him a prior claim to the property. Leschinsky's insistence on fishing below the rack resulted in "a very exciting collision, in which some violence was resorted to on both sides, though no deadly weapons were used."[17] As Leschinsky subsequently took himself off, there seems to be no doubt about who won the fight, which is hardly surprising when it is remembered that Stone was an excellent boxer and not averse to taking on a heavier opponent. Although he makes no mention of it in his official report, this was Livingston Stone's honeymoon—he had just been married in April after a courtship which began when he was called to the pulpit of the Charlestown Unitarian Church.

Leschinsky was back again the next year, however, taking advantage of a clerical error in the presidential proclamation of 1875 by

[15] Smith, H. M., loc. cit., p. 380.
[16] California Fish Commission. Biennial Report, 1874-75, p. 30.
[17] U. S. Fish Commission. Report, 1875-76, p. 936.

which the principal seining ground had been omitted from the reservation. After a few altercations had disturbed the peace in camp, Stone mounted his horse and rode over the hills to the nearest copy of the State laws, in which he found that it was illegal to seine more than a third of the width of the river. Since Leschinsky had been fishing from more than his share of the river, he was frightened off by threats of durance vile.

The next year, in 1877, to impress upon certain elements of the scanty population of the region that the hatchery was government property and perhaps to protect the Indians, the U. S. Army, in the person of a lieutenant and four privates, was garrisoned at the hatchery. Leschinsky appeared again and was conducted off the premises by a U. S. Marshal. During this season of 1877, Stone was away from Baird most of the time, establishing the Clackamas Hatchery under difficult and trying circumstances, including the complete loss of the first catch of eggs by a sudden rise of the river.

Although the country was still unsettled and uncivilized a year later, the corporal's guard was not in evidence during the season of 1878. There was an Indian scare, a local threat of intertribal war between the McCloud and Yreka Indians, probably part of the great Ghost Dance disturbance of 1878, which made the men at the hatchery so nervous that Stone telegraphed for arms and ammunition. One dark Sunday night, when Stone and an assistant were alone at the hatchery, some prowlers so frightened them that they dared not venture outside to investigate, but locked all the doors against what might have been a band of desperadoes, lurking in the bushes and planning to cut their throats. A week later, two robbers, perhaps the same men, stole 20 demijohns of whiskey (as well as his ready cash) from a teamster stopping over at the hatchery and started a drunken debauch among the Indians.

With the sixth report of operations at Baird (1879) the narrative became more business like and less entertaining to the general reader, although there is an interesting account of the establishment of the Crooks Creek trout ponds a few miles up the river from Baird.[18] It was during this first summer at the trout station that Loren Green had his brush with the Indians. It was evidently an eventful summer for the Greens, as Loren also had an encounter with a mountain lion (whose closer acquaintance he avoided by jumping into his boat) and Myron Green was bitten by a tarantula. The treatment for this latter calamity was an external application of moist tobacco and a tumblerful of alcohol internally—somewhat diluted by water. "I mention these incidents," remarked Stone, for the benefit of his colleagues in the settled East, "merely to show that with tarantulas, scorpions, rattlesnakes, Indians, panthers and threats of murder our course here is not wholly over a path of roses."[19] The operations at the salmon hatchery proceeded without notable incident during this season; the army was back, the Indians docile, and two racks were used for the first time. Grilse appeared to be the dominant element of the run this year, a fact which was blamed on the intensive fishery by the

[18] The story of the work at the trout ponds has been recently reviewed by J. H. Wales in his "General report of investigations on the McCloud River drainage in 1938." California Fish and Game, vol. 25, no. 4, pp. 272-309, 1939.

[19] U. S. Fish Commission. Report, 1879, p. 718.

now numerous canneries on the lower river. That the salmon could support such a large canning industry seemed to prove, according to Stone and the California Fish Commissioners, that Baird Hatchery was the major factor in the increase of the salmon in the Sacramento River.

Perhaps the most significant item in the 1879 report is the recommendation that a trained biologist be added to the staff and that scientific investigation be a regular part of the work at the hatchery. Had this suggestion been adopted and the precedent of an adequate check-up of hatchery effort been established, our knowledge of the salmon might have advanced beyond the rudimentary stage in which it is even today, 70 years after the establishment of Baird Hatchery.

FIG. 33. Baird Hatchery as reconstructed after the flood of 1881.

There is nothing eventful in the report of operations at Baird for 1880, but in January, 1881, an epic flood in northern California carried away practically the entire establishment and the hatchery had to be completely rebuilt on higher ground. Livingston Stone was evidently at his best when building something, and in this report, the last long one published, we find a complete description of the harrowing nights of February 2 and 3 when the McCloud River rose 26 feet, carrying all before it, and the vivid story of rebuilding the hatchery to the tune of hammers on new boards and the shouts of the teamsters urging their horses on in the difficult task of grading rocky hillsides for safer building sites. All through the hot summer the work went on, from May 23 to September 1, and in that time the force of 20 white men and a dozen Indians had built a substantial mess house, hatchery building and stable, as well as a bridge and rack across

the river. It was also necessary to fill in the bottom of the seining ground and make new boats which served as floats for the current wheel. Their troubles were not over with the rebuilding of the hatchery, however, for they had hardly completed their work and begun the season's operations when some debris rammed the current wheel, putting it out of commission. For 17 hours the Indians supplied water to the hatchery troughs by a bucket line while the wheel was being repaired.

After this last great effort, Stone's career at Baird was almost anticlimactic. In 1883 the construction of the railroad along the Little Sacramento River north of Redding so affected the salmon that only a million eggs were taken, and operations were suspended at Baird from 1884 to 1887, inclusive. The Crooks Creek work with the trout was continued during this time. The season for egg taking receded each year, indicating a diminution of the trout population of the river, and in 1887 this work was abandoned, it having been decided that the establishment of the rainbow trout in eastern states made it unnecessary to continue gathering eggs at the McCloud River station.

Livingston Stone was recommended for the position of U. S. Commissioner of Fisheries after the death of Professor Baird in 1887, by his old friend Seth Green. Stone declined this honor, however, as he believed that outdoor life was essential to his health. A few months later, in 1888, Stone was made field superintendent for the Pacific Coast, with instructions from the new Commissioner, Marshall McDonald, to intensify the fish-cultural program and to arrange for the acquisition of Clackamas Hatchery from the State of Oregon. Baird was opened as a salmon station for the 1888 season under the supervision of George B. Williams, and Stone spent much of his time at the Clackamas Hatchery, which he succeeded in obtaining for the Federal Government without cost. During the summer of the following year, Stone was one of a party under the leadership of Tarleton H. Bean, investigating the salmon fisheries of Alaska, particularly on Kodiak and Afognak islands. Stone advocated the establishment of a hatchery on Afognak Island and was instrumental in having the island set aside as a fish-cultural reserve in 1892.

After the resignation of Williams as superintendent of Baird in 1892, Stone returned to his first post, where he remained in charge until 1897.[20] By this time his son had reached high school age and his wife longed for the social environment in which she had been raised, so on July 10, 1897, at his own request, Livingston Stone was transferred to Cape Vincent Hatchery, New York.

During Stone's last years at Baird the custom of employing college students for summer work at a dollar a day had become established, and many men who are now prominent in the universities and museums of the country can look back on their summer's work at Baird with pleasant memories of the old Indians and their feasts, of the Widow Derby's boarding house, and of Livingston Stone himself, bewhiskered and favoring a straw hat and shirt sleeves, partial to those young men who could give him a good game of tennis. The foreman during those days was Theodore Bass, whose principal claims

[20] According to the record in the office of the U. S. Fish and Wildlife Service, Stone was furloughed March 31, 1890. What he did from that date until his return to Baird August 1, 1892, is not mentioned.

to fame were his 14 children and the doubtful honor of having had his horse stolen by Joaquin Miller.[21]

Although Livingston Stone was past 60 when he reluctantly left Baird, realizing that he would never again see the place he had come to love, he had not yet retired but kept his new post at Cape Vincent for nine years. He could still play a good game of tennis and

FIG. 34. The current wheel at Baird Hatchery.

apparently retained much of the energy which had carried him through the strenuous pioneering days at Baird. As America's senior fish-culturist, he was called upon to supply his reminiscences for the National Fisheries Congress in 1898, and in 1903 took part in the ceremonies in which the granite boulder memorial to Professor Baird at Woods Hole was dedicated. When he retired in 1906 at the age of

[21] The writer wishes to acknowledge his indebtedness to Dr. Alvin R. Seale, Director of the Steinhart Aquarium, San Francisco, for these reminiscences.

70, Stone had completed 40 years in the cause of American fish culture. He had seen it grow from its beginnings in the little private trout hatcheries of New England to the far flung enterprise of the U. S. Bureau of Fisheries. The vocation he had adopted in 1866 to save his health had not failed him and in his turn he had been one of its most prominent figures for the greater part of his life. He spent the remaining years of his life with his family in Pittsburgh, his last years clouded by a failing memory. He died on December 24, 1912, at the age of 77 years, and is buried in Boston's historic Mount Auburn cemetery.

III

After Stone's departure from California, Baird Hatchery continued to operate about as usual until 1909, handling several million eggs each season. In 1903 and 1905 over 25,000,000 eggs were taken, a huge increase unexplained in the reports. The records for 1910 were not published, and in 1911 only 60,000 eggs were taken from the McCloud River—the end was in sight. Only once after 1911, in 1931, were more than a million and a half eggs taken, while for many years the collections were negligible. During these later years Baird was primarily a handling station for eggs from Battle Creek and Mill Creek hatcheries, established in 1896 and 1901, respectively. The impossibility of determining, from the published records, the comparative size and composition of the runs from year to year with any accuracy, and the total lack of any reliable figures on the exact numbers of eggs taken or the losses incurred during incubation for the 60 years of operations at Baird make it impossible to determine the effect of Baird Hatchery on the Sacramento River salmon fishery.[22]

It is not surprising that the original plan of establishing the Pacific salmon in eastern waters to replace the Atlantic salmon did not succeed; at that time very little was known about the Pacific salmon, and it has only been conceded in the last few years that a thorough preliminary study of the fish and the waters into which they are to be transferred should be made before any attempt to transfer them is resumed. In the 1906 Report of the U. S. Commissioner of Fisheries the failure to establish the chinook salmon in eastern waters was admitted. It was suggested, by way of explanation, that this species was too large and robust for the smaller eastern streams. Thereafter several attempts were made to establish the smaller silver and humpback salmons, but without success. Rumors of small salmon runs from species introduced in the East turn up from time to time, but Huntsman and Dymond discount these rumors and deny that there is any evidence that introduced Pacific salmon have produced a second generation in Atlantic coast streams.[23] The recent capture of two adult chinooks off the mouth of the Pemaquid River in Maine has revived interest in transferring the chinook, but it may be several years before the necessary investigations are completed and another experiment in transferring these fish is made.[24]

[22] That hatchery records still left much to be desired even as late as 1935, when Baird was in its final season, is evident from the article on hatchery records by M. C. James in the "Progressive Fish Culturist," no. 2, pp. 1-4, 1935.

[23] Huntsman, A. G., and Dymond, J. R. Pacific salmon not established in Atlantic waters. Science, vol. 91, no. 2367, pp. 447-449, 1940.

[24] U. S. Fish and Wildlife Service. Fisheries Service Bulletin, no. 306, pp. 1-2, 1940.

Whether this policy leads to successful introduction or not, it is an advance over the days when fish were promiscuously introduced into all sorts of waters, with the avowed hope that something would "take" somewhere. As Stone put it, salmon were introduced into "many places in Eastern States, where they will undoubtedly be a total failure, but should the Commission make a success of a single river * * * it would pay for all that has been expended in this direction in all the other waters of the United States."[25] California's share

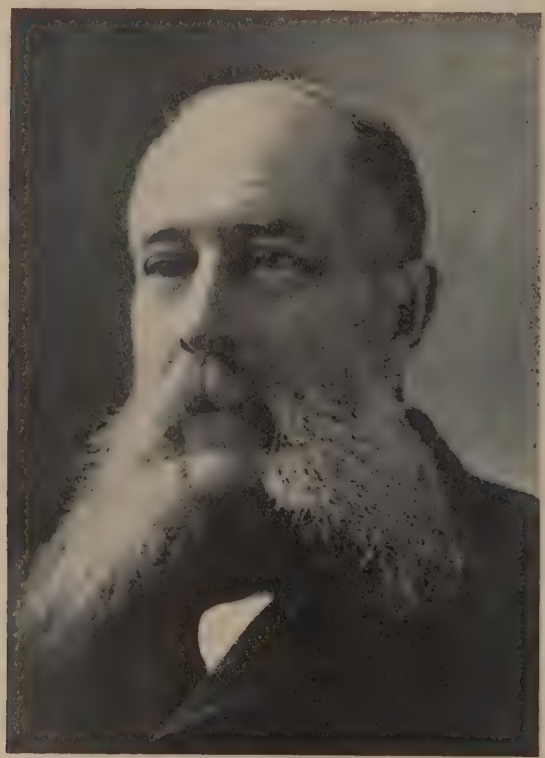

FIG. 35. Livingston Stone, about 1905, shortly before his retirement from the U. S. Bureau of Fisheries.

of this epidemic of fish transferring was marked by several conspicuous successes, notably the shad, catfish and striped bass, but the introduction of the carp, in which Stone had no part, can hardly be considered an unmixed blessing. Because of the paucity of desirable native fishes in California rivers the introduction of many of these species was well justified. On the other hand, while the virtual extermination of the sturgeon from California waters can not be blamed entirely upon the introduction of other species, it does not seem unreasonable to assume that these introductions had some influence

[25] California Fish Commission. Biennial Report, 1874-75, p. 18.

on the depletion of the sturgeon, as well as contributing toward the reduction of less important native species. Early objections to the introduction of this or that fish were overruled on the grounds that the plan was to introduce everybody's favorite fish, and even a few Atlantic salmon were released at Redding, a veritable gesture of carrying coals to Newcastle. Promiscuous introductions are now frowned upon and our various fish and game commissions have at least advanced beyond the unenlightened attitude of the California Fish Commissioners of 1874, who advocated that nine-tenths of the sea lions be shot and their oil be used for lubricating purposes because they were suspected of destroying more salmon than the fishermen.

Equally fantastic were the claims made for the share of the Baird Hatchery in the increase of the salmon fishery on the Sacramento. In 1874 the policy of returning a large number of eggs to the McCloud River at Baird was adopted in order to build up the run, and by 1877 the increased fishery was considered conclusive evidence of the success of the hatchery. Although it now seems obvious that the increase was primarily due to the intensified fishing effort, it must be remembered that the life cycle of the chinook salmon was misunderstood for many years. Livingston Stone, although recognizing that the majority of the salmon in the McCloud River were several years old, speculated on the possibility of the fish spawning in other rivers before their final migration, and the California Fish Commission refused to believe that the salmon spawned but once. "It if were the fact," the Commissioners contended, "* * * it would detract from their value."[26]

The principal basis for the assertions of the extravagant claims for the hatchery in its early years was the misconception of the efficiency of natural reproduction, evidently based on nothing more than an *a priori* assumption that nature was inherently wasteful and inefficient. Stone in his first report, part of which consisted of answers to a series of questions written out by Professor Baird, wrote "No one knows" opposite Baird's inquiry on the survival of naturally spawned eggs. At some time or another, he did dig into a nest, recovered some eggs, and found but 8 per cent of them "vitalised."[27] According to the 1878-79 Biennial Report of the California Fish Commission, "in a state of nature, only two eggs in a thousand hatch." No authority is given for this interesting statement, however.

No attempt seems to have been made to investigate the life of the salmon in California until 1896, nearly 18 years after Stone's request for a biologist as part of the regular staff at Baird Hatchery. In that year studies of downstream migration were begun by N. B. Scofield and A. B. Alexander. This investigation was continued from 1897 to 1903 under the direction of Cloudsley Rutter, but was based at the

[26] California Fish Commission Biennial Report, 1876-77, p. 7. That the chinook salmon spawns but once and then dies was first proven conclusively by Evermann's investigations in Idaho in 1895 ("A report upon salmon investigations in the headwaters of the Columbia together with notes upon the fishes observed in that state in 1894 and 1895." U. S. Fish Commission. Bulletin, vol. 16 (1896), pp. 149-202, 1897). Stone's views on the natural history of the chinook, together with a brief history of Baird and fish-cultural methods, follows Evermann's paper in the same volume (pp. 203-235).

[27] The only reference found to this is in Robert Barnwell Roosevelt's "The game fish of the northern states and British provinces" (New York, Orange Judd Co., 1884). This seems to be based on a conversation with Stone (*cf.* p. 235). In his 1896 paper (loc. cit.) Stone states that the percentage of survival of naturally *spawned* eggs is unknown.

Battle Creek Hatchery. During the summers of 1901 and 1902, C. W. Greene made studies of the physiological changes undergone by the salmon during migration, spending most of his time at Baird.[28] It was during the study by Rutter and his assistants that the first serious attempt was made to observe the spawning of chinook salmon and determine natural losses. As excellent as Rutter's work was in other respects, his observations of the spawning process were so inaccurate that he concluded that the female salmon dug holes in the gravel to loosen the eggs in her body and that no eggs were deposited in the nest at all but simply released to find their way into the gravel.[29] It is not surprising that he should have concluded from such observations that the natural loss was 99 per cent. As controversial as these findings appear to present day investigators, they were unchallenged until the appearance of Hobbs' classic paper in 1937 on the natural reproduction of salmon and trout in New Zealand.[30] The mere fact that the salmon have persisted in some of the Central Valley streams where there are no hatcheries, despite the steady encroachment on their spawning grounds by hydroelectric and irrigation projects and a heavy fishery indicates the remarkable tenacity of the species and tends to support Hobbs' contention that the natural reproduction of the salmon is a highly efficient process.

On the other hand, the high claims made for artificial propagation by hatchery proponents are not supported by the records of the three northern California hatcheries, Baird, Battle Creek and Mill Creek. While these records must be taken with a grain of salt, they do not exaggerate the numbers of eggs taken. In many cases the figures published in the reports of the U. S. Commissioner of Fisheries are considerably lower than the original hatchery records (*cf.* appendix tables 19-20 of Hanson, Smith and Needham, "An investigation of fish-salvage problems in relation to Shasta Dam." U. S. Bureau of Fisheries. Special Scientific Report, No. 10, 200 pp., 1940), indicating some sort of double entry method of accounting for losses to eggs in the hatcheries. Furthermore, it must be remembered that the total number of eggs collected at a hatchery is not an accurate indication of the size of the run since early flash floods frequently made it impossible to gather a large number of eggs from good runs, while poor runs may have supplied large totals in years of favorable weather conditions. Bearing these sources of error in mind, however, some interesting conclusions can be deduced from the records as summarized in the accompanying table.

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[28] Greene, C. W. Physiological studies of the chinook salmon. U. S. Bureau of Fisheries. Bulletin, vol. 24 (1904), pp. 429-456, 1905.

[29] Rutter, Cloudsley M. Natural history of the quinnat salmon. A report of investigations in the Sacramento River, 1896-1901. U. S. Fish Commission. Bulletin, vol. 22 (1902), pp. 65-141, 1904. Perhaps Rutter did not have the time to dig thoroughly into the nests; it often requires several hours to find the pockets of eggs in a single nest, especially in the murky Sacramento. In addition to the salmon investigation, Rutter was directing a survey of the sea lion population from Puget Sound to San Diego, and in 1902 began a survey of the salmon fishery of Alaska. He died suddenly in 1903 while working on the embryology of the salmon.

[30] Hobbs, D. F. Natural reproduction of quinnat salmon, brown and rainbow trout in certain New Zealand waters. New Zealand. Marine Dept. Fisheries Bulletin, no. 6, 104 pp., 1937. Perhaps it is poetic justice that this study, which proved that losses to eggs under natural conditions compared favorably with the rosier claims of the fish culturists, should have been made with salmon introduced to New Zealand from Baird Hatchery.

The record of Baird reflects the difficulties of seining fish in the McCloud River more than it does the abundance of fish in that stream, but in later years the comments submitted with the records mention the scarcity of fish in the river, and it is apparent that the last decline had begun before the effects of the opening of the Glenn-Colusa ditch in 1910 should have been evident and certainly before the construction of the Anderson-Cottonwood Irrigation District Dam at Redding in 1917. As a matter of fact, from 1919 to 1926, with the exception of 1921, a million and a half eggs were taken annually at Baird although the dam was without a proper fishway until 1927, whereas the collections from 1911 to 1919 were negligible. It is also interesting to note that egg collections dropped to zero in 1927 and were not very much more than that during the last years of Baird's existence as an active fish hatchery with the exception of 1931, which was a good year at all three hatcheries. It was necessary to open the racks and permit the surplus fish to ascend the streams and spawn naturally during that season. During the last active season at Baird, that of 1935, only 5,200 eggs were taken (probably from a single female) and 1,500,000 were transferred from Battle Creek.

The records of Battle and Mill creek hatcheries are more interesting in that they reveal a steady drain upon the spawning populations of these streams without destroying the runs. From 1901 to 1912 there is no mention of any fry having been released in the streams from which the eggs were taken, and the practice during this period was to ship most of the eggs to the California State hatchery at Sisson (Mount Shasta). Most of the fry from these eggs were released in the upper Sacramento River. After 1908 the egg take in these streams dropped and in 1913 nearly five million fry were returned to Battle Creek and the attempt to build up the Mill Creek run began a year later. The egg collections declined steadily, however, until about 1920, after which there was no significant fluctuation. This may have been determined in part by the dire financial straits of the U. S. Bureau of Fisheries about that time, but as far as the record is concerned, the effect of the hatchery operations and the various transfers of eggs from one place to another on the balance of the salmon population among the three streams was insignificant. It would appear from these records that the runs in Battle and Mill creeks include a considerable number of fish that have strayed from the run in the main river. As a result of a marking experiment in 1920, in which fish were released from Mount Shasta Hatchery (from eggs taken at Mill Creek), and recoveries made in Battle and Mill creeks, Snyder concluded provisionally that "such (fish) as return are probably scattered over the entire basin, or because of adverse conditions they are forced to enter tributaries before they are able to reach the one into which they were originally introduced."[81]

[81] Snyder, J. O. Salmon of the Klamath River, California. California. Division of Fish and Game. Fish Bulletin, no. 34, p. 71, 1931. In this experiment, 15,400 fry, raised at Mount Shasta Hatchery from eggs taken at Mill Creek, were marked and released in Sullaway Creek at the hatchery. None of these fish appear to have returned to Sullaway Creek, although six were recovered from Mill Creek and fifteen from Battle Creek. Although this and similar experiments have been accepted as support of the home stream (or home drainage basin) theory, it might also be accepted as an indication that the Mill and Battle Creek runs are more in the nature of dispersions from a single main run, subject to the variations in stream conditions from year to year. Although Rich ("Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska," *in* "The migration and conservation of salmon," American Association for the Advancement of Science. Publication, no. 8, pp. 45-50, 1939) maintains that "practical conservation

In 1903 work was intensified at the hatcheries and 27,350,000 eggs were taken at Baird. The fishery, in the meanwhile, was declining and the canneries were suspended after the 1905 season. The mild-cure catch increased slightly from 1903 to 1906 and then dropped but reached a record high of over 4,000,000 pounds in both 1909 and 1910. Over a hundred million eggs had been taken by the three hatcheries in 1905, and the subsequent release of the fry from Mount Shasta Hatchery may conceivably have had some effect on this increase, although it is also possible that 1909 and 1910 were simply good years for salmon, comparable to the 1940 season. Although the canneries were closed after 1919 and the mild-cure catch fell considerably below that of former years, there was no significant increase in egg collections that might be attributed to a greater escapement.

In recent years the river fishery has declined steadily, falling below the 500,000 pound mark on several occasions, but this does not indicate the true value of the Sacramento River as a salmon stream, since most of the fishing effort has been transferred to the ocean.[32] The value of this fishery is one of the crucial points involved in the selection of a salvage plan to replace the spawning grounds which are now being cut off by the construction of Shasta Dam. The cost of whatever plan is adopted must be balanced against the value of the fishery in terms of dollars and cents.

As a result of an investigation begun in 1938 by the U. S. Bureau of Reclamation of salmon biology and stream conditions in northern California (which was, incidentally, based at Baird) several salvage plans were conceived. Because there is so very little water left in the region, all the plans required hatcheries, racks and waterworks, in one case even the rehabilitation of an entire stream, Stillwater Creek.[33] The plan now under consideration involves a system of racks in the Sacramento River between Battle Creek and Redding to hold fall run salmon in enclosures where they will be expected to spawn, and a huge hatchery, one of the world's largest, on Battle Creek to handle the eggs from spring and early fall run fish. Whether the racks will work or not, no one is certain as the scheme has never been tried before, but hatcheries have been none too successful in that part of the world, however efficient they may have been in other regions. Baird Hatchery would probably have been abandoned in any event. It is not unreasonable to assume that Livingston Stone, were he alive today, would admit

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measures must be based on the 'home stream theory' as an essentially correct statement" (p. 47), it would not appear that proposals to divert runs from one stream to another in the upper Sacramento River drainage by the transfer of one or two cycles of adults will be successful on the basis of the scanty information available. Such a program may mean the perpetual hauling of adult salmon from collecting stations to streams in which they are to spawn or be held for ripening and subsequent artificial propagation. We may have a better understanding of this matter when the results of the wholesale transfers of fish to the tributaries of the Columbia River between Rock Island and Grand Coulee dams become apparent, although those streams are more constant, in flow at least, than the streams in northern California. An experimental transfer of salmon from Redding to Deer Creek, 18 miles north of Chico, is being made during the summer of 1941. It is hoped that this experiment will demonstrate the feasibility of holding a large number of spring-run salmon in this stream during the hot summer, but any effect on the salmon population of Deer Creek cannot be anticipated for several years, however.

[32] Clark, G. H. California salmon catch records. California Fish and Game, vol. 26, no. 1, pp. 49-66, 1940.

[33] The report of this survey, "An investigation of fish-salvage problems in relation to Shasta Dam," by H. A. Hanson, O. R. Smith and P. R. Needham, mimeographed as Special Scientific Report, no. 10 (1940) of the U. S. Bureau of Fisheries, has been published in a condensed version in vol. 70 (1941) of the Transactions, American Fisheries Society.

that another hatchery seems a poor substitute for California's once magnificent river system and that here at last is the doom of the salmon which he foretold. Nor would he fail to appreciate the irony of the fact that the biological investigators who sought to determine a salvage plan were based at Baird after it was no longer a hatchery.

It is doubtful, however, that the Chinook salmon will become entirely extinct in the rivers of central California, for there are still a few accessible spawning areas left and in time the species may adjust itself to the remainder of its territory if it is adequately protected from poachers on the spawning riffles and its seaward migrating young screened out of diversions. The problem of salvaging salmon from the streams which will be blocked by Shasta Dam is so difficult that any attempt to cope with it may be unsuccessful. It should not be forgotten that there is another dam on the Sacramento River in the plans for the development of the State's water resources. The site for this dam is at Table Mountain near Red Bluff and its construction would wipe out the salvage investment between it and Shasta Dam, as it would be 300 feet high.[34]

To the engineer who plans the dams and the politician who promotes them for the glory of his constituents, the salmon have little sentimental value, although in fairness to these gentlemen it must be said that the fish had been given up for lost in California long before this and they could hardly be expected to share the biologist's peculiar interest in the preservation of a species for its own sake. Yet, whoever has seen the magnificent leap of a salmon over the crest of a weir can not but regret its passing from so many of our streams. The great runs are gone and with them have vanished the simple Indians whose life depended on them, and soon the rivers themselves will be gone, their ancient beds far beneath the surfaces of the reservoirs. While speculation about the value of this sort of progress is vain (and there are many economists who deny the necessity for some of these grandiose projects) the destruction or impairment of an important natural resource is a high price for such progress, and it has been more than unfortunate that actual construction of the dams involved was begun without any consideration of the fish runs in the rivers.

"The unpardonable indifference of Californians" toward their most valuable fish resource which so disgusted Professor Baird in the 80's has not changed perceptibly; if anything, it has increased. Yet the salmon have persisted and even increased in some years despite the works of man and his indifference to their welfare. Now, man, as an unwitting by-product of his great power and irrigation scheme, has started an experiment with the salmon's life which will be irrevocable. Whether or not it succeeds will make but little difference, for it

[34] The present agitation to hurry completion of power facilities of various projects in the name of the national emergency is a serious danger to wildlife, as pointed out by Ira N. Gabrielson, director of the U. S. Fish and Wildlife Service, in an address to the Sixth North American Wildlife Congress. This agitation is especially strong in behalf of Shasta Dam. According to George C. Tenney, editor of "Electrical West," the power supply for northern California is adequate, however, and there seems to be a coincidence between these so-called power shortages and the necessity for large appropriations to complete the projects. The inconsistency of blocking the expansion plans of a private power company while insisting upon the early completion of Shasta Dam caused Tenney to remark, "Under the circumstances, there is room for questioning all but the political validity of these so-called 'power shortage' claims." (San Francisco Chronicle, February 8, 1941, p. 15.) Since the Pacific Gas and Electric Company has now been granted permission to carry out its expansion program, it would seem reasonable to assume that there should now be no necessity to adopt inadequate salmon salvage measures at Shasta Dam simply to complete the project ahead of schedule.

will be too late to make any changes when the result is finally known. Let us hope that the salmon will persist, even if only as a scattered remnant of its once abundant legions.

We should not forget, as did a recent writer on the history of the Sacramento River,[35] that once salmon canning was one of California's major industries and that the fish were first canned in this State. Nor should we forget that there was a day when our salmon were so highly esteemed that an energetic man with flowing Dundrearies came 3,000 miles to gather their eggs in an attempt to plant the fish in his own New England.

TABLE 1

Chinook Salmon Hatchery Operations, Sacramento River, 1896-1935[a]

(All figures in thousands, i.e., 1,000 = 1,000,000)

Year	McCloud River (Baird)		Battle Creek		Mill Creek		Eggs sent to Mt. Shasta
	Eggs taken	Fry released	Eggs taken	Fry released	Eggs taken	Fry released	
1896	5,000	2,000	25,852	10,900			18,645
1897	9,194	6,916	48,527	44,280			6,255
1898	16,568	3,263	19,429				31,620
1899	6,415	4,729	1,610				1,905
1900	2,139	889	3,920				2,021
1901	8,932	2,115	10,059		2,561		17,149
1902	1,065	1,618	5,684		3,880		7,455
1903	27,352	2,350	21,354		15,891		58,624
1904	8,661	7,561	50,644		36,719		87,170
1905	25,743	3,488	49,032		33,110		96,190
1906	2,984	2,512	32,640		37,752		63,671
1907	10,442	4,780	36,379		18,132		56,493
1908	5,078	3,590	14,006		13,193		26,599
1909	7,331	2,286	7,358		15,849		27,214
1910	(Records for	1910 were not	published)				32,952
1911	60	7,243	11,090		9,547		16,254
1912	495	2,195	6,270		10,327		14,522
1913	3	3,011	15,232	4,793	14,782		22,796
1914		2,875	19,969	5,001	21,669	3,740	34,301
1915		2,464	10,414	6,155	12,750	9,750	18,872
1916		3,702	14,293	5,695	7,026	4,863	7,027
1917		2,760	4,810	4,050	17,264		14,321
1918		2,280	5,384	4,509	17,284	3,498	11,802
1919	1,350	1,350	4,078	3,619	6,358	2,122	4,000
1920	1,349	1,465	2,450	1,781	5,460	1,347	3,000
1921		1,500	2,386	1,386	1,986	1,486	
1922	1,521	1,466	1,587	1,587	791	750	
1923	1,000	1,242	1,620	2,300	3,012	1,770	
1924	1,200	1,133	887	1,330	2,300	1,598	
1925	1,590	1,590	2,082	2,682	3,270	2,550	
1926	1,545	1,545	4,585	4,585	3,175	3,175	
1927		1,642	1,811	1,433	3,405	2,520	
1928	250	[b]1,211	2,347	2,189	2,350	1,312	
1929	500	[b]1,956	7,674	5,301	1,800	2,385	
1930	160	3,075	11,130	8,840	5,137	4,116	
1931	10,776?	6,240	9,507	9,507	8,999	3,915	3,780
1932	857	857	3,417	3,417	1,667	1,667	
1933	30	1,168	1,379	1,379	2,309	1,277	
1934		1,495	3,492	3,492	4,000	2,369	
1935	5	1,500	8,500	4,055	4,500	4,761	

[a] Record of hatchery operations compiled from the tables "Hatchery Operations" and "Eggs Distributed," in Reports of U. S. Bureau of Fisheries, 1896-1936. In many cases it was necessary to arrive at the figures given in this table by addition or subtraction of published figures; hence a balance between eggs taken and fry released at a station indicates that the figure has been derived from the tables and does not indicate a 100 per cent success in hatchery operations. In addition to the eggs sent to Mt. Shasta Hatchery, eggs were also sent to the Eel River (in 1898 and 1901 these were not separated from the Mt. Shasta figures) for many years, and several shipments were also made to the Brookdale Hatchery near Santa Cruz.

[b] The larger part of these fry were released below the Anderson-Cottonwood Irrigation District Dam, in the Sacramento River.

[35] Dana, Julian. The Sacramento, river of gold. New York, Farrar & Rinehart, 1939. 294 pp.

CALIFORNIA'S GAME MANAGEMENT AREA LAW[1]

By August Bade

Bureau of Game Farms
California Division of Fish and Game

If there is any one particular indictment that might be laid at the door of all fish and game departments and conservation groups of past decades, it is "lack of management" in the conduct of fish and game matters. For many years there has been a feeling of animosity growing up between sportsmen and landowners. Little of a constructive nature has been done to remedy this situation. On account of damage by hunters to crops, fences, telephone lines, live stock and general farm equipment, more trespass signs appear each year.

This damage is not a matter of fancy, but on the contrary in many cases a real one that can be measured by the yardstick of the dollar. During the past year, two very responsible men who either own or manage large holdings in the Delta area northwest of Stockton and in the Sacramento Valley have reported damage amounting to $2,500. In the Delta area it was necessary to drive two wells in order to extinguish fires set by careless pheasant hunters.

The farmer or landowner has certain property rights that have not received proper recognition in the past. In order to protect his property he has resorted to the only means at his command—the trespass law. In actual practice, unless the landowner could show real damage he did not get much satisfaction when he tried to prosecute violators for trespass. The landowner has felt for a long time that while much of the wild game lived on his property and to a certain extent fed on his land and enjoyed protection, he, the landowner, received nothing in return for these considerations.

It is little wonder then that the landowner looks with so much favor and real enthusiasm on the recently enacted Game Management Area Law that has in effect said, "Now I can receive something for the use of my land as a production area for upland game birds. I can produce a crop of pheasants or quail by complying with the rules and regulations of the Fish and Game Commission and market them the same as any other farm crop and at the same time provide a place for responsible sportsmen to hunt."

In short the Game Management Area Law, enacted in 1939 (California Fish and Game Code, Div. I, Chapt. 5) provides that "any person who owns or controls the shooting rights on a tract of land of 120 acres or more may apply to the commission for a game management area license authorizing the killing by shooting of quail and pheasants, or either, upon such land in accordance with the provisions of this chapter." The law also charges the Fish and Game Commission with

[1] Submitted for publication, January 15, 1941.

the setting up of the rules and regulations under which the act is carried out. The Commission has promulgated these rules and regulations and has designated the Bureau of Game Farms as the administering agent.

The cost of this license when granted is 10 dollars per year and permits the operator of the area to stock it with either quail or pheasants or both and to have a season within the period from September 1 to January 31. According to the rules and regulations as set up by the Commission, this shooting season has been set as October 1 to January 15, which gives a season of three and one-half months, during which time pheasants and quail may be lawfully taken by shooting on all such areas.

FIG. 36. Banding a pheasant for release on a game management area near Woodland, Yolo County. The birds for the managed areas are all either purchased from private game farms or raised by the operators themselves. The Division of Fish and Game bands all birds and supervises their liberation.

The law clearly sets forth that all birds used by the operators for the stocking of their areas must be either reared on the premises or purchased by the operator from licensed or commercial game breeders. The State does not furnish this stock.

Any one owning or controlling the shooting rights on a tract of land of 120 acres or more, who wishes to create a game managed area, can apply for a license to the Fish and Game Commission through the Bureau of Game Farms, State Game Farm, Yountville. An agent of the Game Farms will then visit the place in question and consult with the applicant as to the fitness of the place for a game managed project. If the Bureau of Game Farms approves the area, a recommendation is made to the Commission that a license be granted. If, in the judgment of the Bureau the granting of such license would not be

in the interests of the general good, an adverse report is made to the Commission.

When the operator secures a license he may then proceed with the posting of the land. The Commission designates the size and wording of these signs. Each sign must be at least 12 by 18 inches, spaced not over 500 feet apart on all exterior boundaries, and contain the words "Game Management Area—Authorized under Regulation of the Fish and Game Commission—No Trespassing."

The act itself says that not more than 90 per cent of the birds released on the area may be lawfully taken. But the Commission has said in its rules and regulations that but 80 per cent of the number released may be lawfully taken on any game management area. All birds remaining on a game managed area at the close of the season become the property of the State and are not to be considered when calculating the number of birds which may be lawfully taken on this area the following season. Only birds which have been killed by shooting may be lawfully taken from a game managed area.

Before any birds may be lawfully taken from a game managed area, a metal tag must be attached to the body of the bird and remain there until the bird is ready for consumption.

In order to obtain additional information, the Commission at its own expense bands all birds at the time of release on game managed areas. When recovered, these serially numbered leg bands help to determine how long birds live, how far they may travel, and what numbers of wild birds are taken in proportion to released birds.

According to the game management area law the licensed operator may charge a fee for the privilege of shooting birds on his area. If a fee is charged it may be on the basis of the individual bird, a day, or the season, and the amount thereof shall be stated on a written permit which shall be issued to the hunter by the operator. The Commission does not set the fee that may be charged by the operator.

Each operator of a game managed area is required to render a monthly report to the Commission in which the number of hunters using the area each day is given; the number and kind of birds taken, male and female; and such other information as the Commission may deem necessary.

The Commission may require proper care as to sanitary conditions on any licensed premises where birds are reared for release in order to prevent the spread of disease. In case of dispute regarding sanitary conditions the matter will be referred to the Poultry Pathological Laboratory of the University of California.

Any person violating the provisions of the game management area law or the rules and regulations as set up by the Commission is guilty of a misdemeanor, and upon conviction may in the judgment of the court be subjected to a fine of not more than $500 or six months in jail or both fine and imprisonment. The law also provides that in case of misrepresentation or fraud on the part of the operator his license may be revoked after a hearing has satisfied the Commission of such fraud or misrepresentation.

By and large the game management area law seeks to repay the landowner for the use of his land as well as to provide a longer hunting season for the sportsmen who are willing to pay for such privileges,

and at the same time open up a new market for the product of the commercial game breeder. With efficient cooperation from all parties concerned, economic advantage will come to the farmer and game breeder and more pleasure for the real sportsmen.

One of the first complaints coming from sportsmen when the game management area law went into effect was that much valuable public shooting ground was being taken away from them. At first this complaint seemed to have merit but when all the facts are had the picture changes and this is just another one of those things that isn't what it seemed to be.

The first year saw 17 game managed areas organized and 13 of these actually permitted shooting either to club members or the pub-

Fig. 37. Banding and releasing quail on a game managed area near Petaluma, Sonoma County. This area contains 1,000 acres of leased land, only part of which is "quail country," as is shown in the photograph. The operators of this club raised and liberated 529 quail in 1940; during that season 18 hunters killed 279 birds.

lic. The total acreage involved in the 17 areas was 70,318. Of this total 54,751 acres had been closed to public shooting by the landowners before the law was enacted, so all told, but 15,567 acres were directly affected by this law.

What many sportsmen seem to forget is the fact that property owners have certain rights and in the past few years, because of the conduct of men in the field with a gun, have decided to assert their rights and for that reason more land each year is being closed to public shooting. The thoughtless actions of a minority of hunters have brought about the closing of land to all sportsmen. As a general rule, farmers or landowners are good fellows, and if treated as such will usually permit responsible persons the use of their land for shooting purposes.

While the problem of the landowner and the sportsmen seems to present unsurmountable difficulties, if the sportsmen would only realize that the property owner holds the key to the situation, and if the hunters wish to use his land as a hunting ground, the first and most important move is up to the sportsmen. The landowner, because of the treatment he has received, has indicated quite plainly his intentions.

Another complaint that sportsmen have made concerning game managed areas is, "It costs too much to hunt on these areas." And, like other complaints the facts show a somewhat different answer. Seldom does the sportsman count all the costs entailed in either hunting or fishing. If he did, less trips would be taken. As a matter of fact, and these facts have been obtained from men who willingly have told what hunting costs, you can go to some game managed area where public shooting is permitted and although you may pay two or three dollars for a bird, you will expend less in actual money and time than if you drove many miles and took your chances on finding some place where you could hunt, with no assurance that you would be successful.

Taken as a whole the game managed area law has something to offer the unattached sportsmen, but like a great many other new things is not entirely understood. When more experience is had and the program is better understood the sportsman will realize that these game managed areas are providing him with a place to hunt at a reasonable cost and a great many birds that cost him nothing.

Although the law permits 80 per cent of the birds reared and released to be taken, the records, not only in California but in many eastern states, show that not more than 50 per cent of the birds released are actually taken. There is no law which will make a pheasant or quail stay on the property where it was released. In one case last season a pheasant was taken five miles from the point of release at the end of three weeks. As the birds wander from the managed areas, adjacent open land will become stocked at no expense.

Game management means the handling of land so it will be a suitable home for birds and at the same time produce an annual crop of game. In order to accomplish this the operator must plant his land for both food and cover. There is a great difference between a shooting club and a game managed area. During the first year most of the areas were organized and operated as clubs because there was not sufficient time for operators to carry out all the provisions and general ideas of game management. But from here on out, all the best features of game management will be required and most important of all, land must be handled or managed so it will produce and maintain an annual crop of upland game.

OBSERVATIONS ON DUCK DISEASE AT TULARE LAKE BASIN, 1940[1]

By Alfred S. Mays
Bureau of Game Conservation
California Division of Fish and Game

Introduction

Every year in the alkali basins of western United States, botulism, more often called "western duck disease," takes a toll of thousands of our migratory waterfowl. The disease usually strikes in the summer and fall months when water levels are low and warm weather raises the temperature of the water to 65° F. or higher. Tulare Lake Basin in San Joaquin Valley has had its share of trouble from this source in the last few years, and it is in this area that much of the duck rescue work of the California Division of Fish and Game has been conducted.

Western duck disease is an intoxication from ingestion with food and water of toxin produced by the bacterium, *Clostridium botulinum,* type C. This is similar to the types A and B which cause botulism and ptomaine poisoning in human beings. There have been no known cases in which type C has had any ill effect on human beings. During earlier outbreaks of disease in Tulare and Buena Vista lakes, affected birds were picked up by market hunters and sold in markets in San Francisco and Los Angeles. Every year many birds in various stages of *botulinum* poisoning are taken by hunters in their bag of game. These birds have been eaten without any ill effect.

Conditions Under Which Outbreaks Occur

Conditions necessary to cause an outbreak of botulism are the presence of the causative organism, *Clostridium botulinum,* type C, and decaying organic matter in stagnant water at temperatures suitable for the organism to multiply rapidly.

Some of the areas in Tulare Lake Basin are ideal incubators for the development of a culture of the *botulinum* organism. Tulare Lake is a catch basin for the run-off waters of the Kings, Tule and Kaweah rivers and other streams running from the surrounding foothills. There is no outlet and the water does not sink into the ground. Water in the lake is thick with algae and with decaying animal and vegetable matter. There are wide expanses of shallow water and mud flats. There is a deficiency of oxygen in the water as is shown by many fish coming to the surface gasping for air. This is due to the oxygen being consumed during decomposition of organic matter. Water temperature on the mud flats is sometimes as high as 101° F. All this produces a favorable medium for this anaerobic organism to propagate and produce toxin.

[1] Submitted for publication, March, 1941.

Water for irrigation is pumped from the lake to surrounding fields where it may stand for periods of from two days to three months. Fields to be flooded vary in size from a quarter to nine sections. Larger areas take longer to cover with water and are thus more likely to produce an unfavorable condition. Large areas flooded slowly or where the water is allowed to stand for more than a week are almost sure to cause an area of infection. Where water is moved off within a few days there is never any chance for the *botulinum* toxin to become concentrated.

Crops grown in this area are mostly wheat and barley. Cotton, milo maize, flax, rye and oats are also grown but to a lesser extent. As there is no feed for ducks in cotton fields and very little open water there is no disease there. Grain left by the harvesters attracts thou-

FIG. 38. Duck rescue crew of the California Division of Fish and Game collecting sick ducks for treatment, Tulare Lake, 1940.

sands of ducks to feed in the grain fields. After the crop has been harvested and before flooding the fields, the stubble may be grazed by sheep, burned and disked, or just grazed or burned. Treatment of soil or type of crop grown does not seem to have any effect on the occurrence of the disease except that grain on the ground will attract birds to feed in the areas which might contain a concentration of toxin.

Shallow water at temperatures in excess of 65° F., little or no movement in the water and decaying organic matter seem to be the requisites for an outbreak of *botulinum*. However, occurrence of these conditions does not always cause an outbreak. Highest concentrations of toxin seem to be in the mud and shallow water where ducks and shore birds seek grain, insects and other particles of food.

An outbreak of botulism is very sudden. One day a large flight of birds migrating from the north will come into an infected area and the next day there will be hundreds of ducks affected by *botulinum*

that can not rise from the water and some will even be dead in this short time. An accumulation of sick ducks in an area will decoy in more birds, and these will likewise become affected; thus the numbers of sick birds will pyramid with alarming rapidity.

The disease usually continues on through the fall until opening of duck season when hunters take the less active birds in their bag. When

FIG. 39. Sick sprig, showing characteristic attitude of birds affected by *botulinum*. Tulare Lake, 1940.

cold weather comes on, lowered water temperatures cause the *botulinum* organism to change to its harmless spore form. Without apparent reason, outbreaks may subside as suddenly as started, and also the disease may appear under conditions which do not conform to the expected pattern.

Symptoms of Duck Disease

The course of intoxication from *botulinum* when observed in the field seems to be a weakening and progressive paralysis. At no time does the affected bird show any sign of being in any pain.

The first symptom of botulism that is noticed is that the bird rises from the water sluggishly and will not heed danger until it approaches very near. Thus, affected birds are easily taken by predators. Sometimes a bird will flap its wings along the surface of the water for two or three hundred feet, attempting to fly before it is finally able to rise into the air.

The next stage in the progress of the disease is the inability to fly; birds may be able to move rapidly over the surface of the water for some distance with the aid of the wings but they can not take off. They can still swim and dive and can run rapidly over the ground with the aid of wings.

In the next stage the bird can swim well and dive but no longer attempts to fly. It may not be able to dive more than a few inches under the surface and leaves a very noticeable wake showing its course.

The bird has gradually weakened and can now swim only sluggishly and is no longer able to dive. It often makes a silly-appearing attempt to do so with its head under water and feet paddling vigorously in the air. Muscles of the neck have weakened until the bird can not hold its head erect but rests it on the crook of the neck. It may swim very sluggishly or it may sit inactive on the bank or mud flat. A bird may be stuck in the mud in this paralyzed state for several days before dying.

Paralysis finally overtakes the muscles of the neck and the head droops to the ground, the bill and nostrils sometimes becoming plugged with mud. If the bird is in the water it is unable to keep its nostrils out of the water and will drown.

Sometimes nervous manifestations appear that indicate only partial disturbance of some of the nerve centers, which causes lack of coordination of the muscles. The head jerks and sways. There is loss of control of the muscles, which results in quick erratic movements. The bird swims, walks or dives erratically or in circles. Recovery from this stage is rare.

If a concentrated dose of toxin has been taken, death may occur in less than 24 hours. Under other conditions the disease may last several days. Recovery is rare as the affected bird is not strong enough to get away from the infected area. Most of the sick and dead birds are fat and in fine shape unless the course of disease has extended over some time.

Other symptoms which appear when duration of disease is prolonged are swelling of the eyeballs with a mucous secretion that sometimes closes the eyelids. The mouth and throat become dry, giving rise to a hoarse, croaking voice. The voice may disappear altogether and the bird gives only a whisper or hiss when it tries to quack.

FIG. 40. The neck muscles become paralyzed in advanced stages of *Clostridium botulinum* intoxication. Tulare Lake, 1940.

Usually green, sometimes white or yellow slimy excretions come from the intestines. Glands do not secrete oil and the feathers become

dry and do not repel water. An affected bird does not eat or drink and the digestive tract is empty except for a slimy mucous.

Control Measures

Duck rescue crews of the California Division of Fish and Game pick up the helpless birds affected by *botulinum* and with treatment can frequently restore their health. Birds are picked up from boats

FIG. 41. Two male green-winged teal affected by *Clostridium botulinum*. Tulare Lake, 1940.

in the borrow pits and open water, and on foot along the shores and levees. Long-handled poultry nets aid greatly in catching the more active ducks. Traps devised from bait seines were found to be practical when birds were concentrated in a relatively small area and could be herded. It is practically impossible to recover the birds which lie on the deep mud flats. All dead birds are removed from the water and thrown up on dry ground so that there will be no further infection from that source. Four-inch flash bombs are used successfully to drive birds from an infected area before they become affected.

Rescued birds are taken to hospital pens for treatment. Fresh water and shade are essential for any satisfactory proportion of recovery. Using a long glass tube and rubber bulb, each duck is treated with $\frac{1}{4}$ to $\frac{1}{2}$ ounce of 1-5,000 solution of potassium permanganate. In cases where the bird is prostrate, the treatment is repeated three times daily, either with solution or just plain water until the bird is able to drink by itself.

Recovery usually takes from four days to two weeks. When birds are in early stages of the disease, recovery is often very rapid. The bird may be walking around a day or so after being brought to the hospital pens. Death, if such is to be the outcome, is more rapid. A bird which has taken a large amount of toxin may die before reaching the pens or soon after, even though it showed only the first symptoms

of disease when picked up. Stamina of a duck is wonderful, for birds which have been sick for a long time, have lost a lot of flesh and which appear hopeless, will recover with but little help. Birds affected by *botulinum* do not eat or drink until they are beginning to recover. They will drink and rub their eyes to free them of hardened mucous, and will preen their feathers even before they are strong enough to stand up. No food is taken until they are well on the way to recovery. When the bird first starts to eat, it is given egg mash which is high in protein from several different sources. This mash is easily digestible and contains all the necessary ingredients for a balanced food. Later they are fed any grain available—barley, wheat, maize, etc.

Flight feathers are removed from one wing of all birds so that they will not leave the pens before fully recovered. It takes six weeks for these feathers to grow out and by that time the bird is strong enough to care for itself. All birds before being released are tagged with U. S. Fish and Wildlife Service leg bands.

Most ducks and shore birds respond readily to treatment. Spoonbill do well for a while but some of them do not learn to eat in the pens and mortality among them is high. Ruddy ducks and coots will not live for any time in a pen. Suitable food can not be obtained for

FIG. 42. Ducks recovering from the effects of *botulinum* intoxication at Hauser Camp pens, Tulare Lake Basin, October, 1940. A plentiful supply of clean water is essential for recovery.

shorebirds, terns, grebes, etc., so these birds are released as soon as possible, along with other species which can not be cared for satisfactorily.

Recovery from the disease does not produce an immunity. Six birds picked up by rescue crews showed by bands that they had been victims the previous year. Five birds picked up earlier this season recovered from the disease, returned to infected areas and were again picked up by rescue crews.

FIG. 43. Ducks recovering from effects of botulism at Hauser Camp pens, Tulare Lake Basin, October, 1940.

When a flight of birds comes into an infected area, only a small percentage of them become affected, approximately 0.5 to 2 per cent. This percentage will increase as birds continue to feed in the same area but will never affect all the birds. The reason for this may be that only the fatter birds are aggressive feeders and take in more food and water and thus more toxin. Another possibility is that repeated small doses of toxin might produce a temporary immunity or tolerance. The most

FIG. 44. Hauser Camp, Tulare Lake, as seen from the air. 1940.

likely theory seems to be that the areas of highly concentrated toxin are small, relatively.

Causes of Duck Sickness

We encounter a wide assortment of theories as to the cause of sickness among waterfowl:

Lack of grit to grind the food. Although there seems to be no gravel in the soil at Tulare Lake, there is always grit present in the gizzards of dead birds.

Eating mud or bill plugged with mud. This is effect rather than cause of disease. When birds become paralyzed the head drops to the mud and the nostrils become caked with it.

Eating cockleburs. Chickens eating green shoots supposed to be cockleburs have developed a stagger and died soon after. There are very few cockleburs in the Tulare Lake area and ducks and shorebirds are never seen feeding on them. Ducks placed in pens with only cockleburs for food refused to touch them. Green, dry and crushed burs were used. No green shoots were available in the fall of the year. Sandpipers, dowitchers, phalaropes and other shorebirds which contract botulism could not possibly eat these cockleburs.

Eating sour grain. Chickens have eaten sour mash and other sour foods and developed what was probably botulism.

Limberneck. *Botulinum*, type C, is the same organism which causes limberneck in domestic poultry.

Eating dead and decayed fish. Most of the species affected seldom if ever feed on fish, dead or alive.

Intoxication from fermented grain. Alcohol from fermented grain in the fields could not become concentrated enough to cause the symptoms noted, let alone death. However, grain in the flooded areas attracts birds to feed where there has developed a concentration of *botulinum* toxin.

Alkali poisoning and concentration of inorganic salts. This was one of the earlier theories as to the cause of disease in ducks and may be a contributing factor.

Poisonous gases. Marsh gas of methane from decomposition seen bubbling through the water is not concentrated enough to cause such extensive damage.

Eating paddlebugs (*Dytiscus*). Botulism can be caused from birds eating larvae of some insects and there is a possibility that the disease could be conveyed by aquatic insects.

Deficiency in diet. Lack of some factor in diet could not cause such a rapid sickness. As soon as food becomes scarce in an area, ducks will migrate.

The primary cause of botulism among waterfowl in Tulare Lake Basin is the diversion of water from the streams flowing into the lake and the pumping of water from the lake for irrigation. This continual fluctuation and periods of low water level prevent the growth of aquatic plants and expose shallow mud flats where the organism propagates. Change of some agricultural practices would prevent the disease occurring in flooded fields. Where the land is flooded with a good head of water that is not allowed to stand for more than a few days, the *botulinum* organism does not have time to produce toxin concentrated

enough to cause any harm. Any chemical treatment of water or soil over such a large area would be practically impossible because of the prohibitive expense and it would also render the water unfit for agricultural purposes. The ideal condition would be to create a large area of water at constant level and a growth of aquatic plants which would keep oxygen in the water. This would supply a feeding ground for the waterfowl and keep them away from unhealthy conditions. Suitable conditions should keep waterfowl in this area in the numbers which existed before man destroyed their favorite haunts. Availability of fresh water from wells is limited to the northeast side of the basin. Elsewhere in the area there is only salt water or none at all. Chloride content of this salt water is approximately 1500 ppm.

Suggested Experiments

It would be desirable to conduct a number of experiments that might prove of value in the study of *botulinum* in waterfowl. Some experiments that may be suggested are as follows:

FIG. 45. Approximately 200 sprig and mallard rescued on Buena Vista Lake, October, 1940. The trees furnish the shade that is necessary for recovery from botulism.

The *botulinum* organism is almost universal and would survive nearly any attempt to eradicate it from the soil and water. However, the toxin which it produces is less stable and experimentation should give us some way to prevent it from becoming concentrated, or destroying it after it had been formed.

By giving controlled doses to birds, determine the concentration of toxin in mud and water from different areas.

Take samples from questionable areas and find out if toxin has become concentrated before large flights of birds come in.

Determine effect of repeated small doses to find out if tolerance or temporary immunity is developed.

Determine oxygen and nitrate content of water and mud and effect on toxin. Does methane gas in the mud aid production of toxin?

Birds eating fly larvae from dead birds will become affected by disease. Will eating aquatic insects from a highly concentrated area do the same?

Conditions existing at sewage disposal plants in the San Joaquin Valley might prove of value in experimental treatment of water to reduce concentration of toxin.

Antitoxin has been used successfully to treat botulism in domestic poultry and might prove to be an aid in treatment of waterfowl.

Other treatments which might be improvements are: large dose of mineral oil; weak solution of bichloride of mercury (1 to 10 or 15,000); weak solution of lye; washing stomach with bicarbonate of soda solution to remove any toxin which has not yet been absorbed.

Use of salts of any kind is inadvisable as the bird has already been exposed to water that has too much inorganic salt in it. Salts also have a tendency to further dehydrate an already dehydrated duck.

Giving a large number of ducks a complicated treatment would of course be impractical unless it has been proven to be of unquestionable value.

Duck Rescue at Tulare Lake, 1940

During August, September and October, 1940, duck rescue crews of the California Division of Fish and Game handled 5,437 sick water birds in the Tulare Lake area. (See Table 1.)

Of these, 4,152 recovered and were released in a healthy condition. Death resulted in 1,285 cases. Of the number rescued, 5,163 were ducks, of which 3,944 recovered. The remaining birds were shorebirds, gulls, herons, coots, etc.

TABLE 1

Birds Affected by Botulism Rescued at Tulare Lake, 1940

Species	*August*	*September*	*October*	*Total*	*Casualties*	*Recovered*
Ducks:						
Sprig, female	156	603	603	1,362	284	1,078
male	178	585	572	1,335	327	1,008
Green-winged Teal, female	8	244	154	406	96	310
male	28	603	489	1,120	245	875
Spoonbill, male	74	164	137	375	108	267
female	32	124	121	277	75	202
Ruddy Duck	--	16	41	57	16	41
Cinnamon Teal, female	6	44	18	68	22	46
male	5	44	4	53	12	41
Mallard, female	24	12	6	42	13	29
male	16	13	7	36	11	25
Widgeon, female	1	2	9	12	2	10
male	--	3	2	5	1	4
Gadwall, male	--	3	--	3	--	3
female	--	--	1	1	--	1
Redhead, male	3	--	1	4	1	3
female	2	--	--	2	1	1
Fulvous Tree Duck	3	2	--	5	5	0
Coot	12	46	17	75	9	66
Black-necked Stilt	13	25	7	45	9	36
Dowitcher	11	13	46	70	36	34
Sandpiper	--	4	21	25	2	23
Eared Grebe	--	--	16	16	1	15
Avocet	3	3	8	14	4	10
Snowy Egret	--	5	1	6	--	6
Phalarope	2	4	--	6	1	5
Killdeer	--	1	1	2	--	2
Marsh Hawk	--	--	1	1	--	1
Glossy Ibis	--	1	1	2	1	1
Wilson Snipe	--	--	1	1	--	1
Marbled Godwit	1	--	1	2	1	1
Bonaparte Gull	--	--	1	1	--	1
Black Tern	1	--	--	1	--	1
Great Blue Heron	1	1	--	2	1	1
Black-crowned Night Heron	--	2	--	2	1	1
Bittern	--	1	--	1	--	1
Least Bittern	--	1	--	1	--	1
Western Willet	--	--	1	1	--	1
	580	2,569	2,288	5,437	1,285	4,152

TABLE 2

Birds Affected by Botulinum, Recovered and Banded With U. S. Fish and Wildlife Service Bands, 1940

Tulare Lake Basin:

Ducks

Sprig (Dafila acuta tzitzihoa)	1,710
Green-winged Teal (Nettion carolinense)	814
Spoonbill (Spatula clypeata)	351
Cinnamon Teal (Querquedula cyanoptera)	54
Mallard (Anas platyrhynchos platyrhynchos)	49
Ruddy Duck (Erismatura jamaicensis rubida)	9
Widgeon (Mareca americana)	7
Gadwall (Chaulelasmus streperus)	3
Redhead (Nyroca americana)	3
Coot (Fulica americana americana)	15
Long-billed Dowitcher (Limnodromus griseus scolopaceus)	2
Marbled Godwit (Limosa fedoa)	1
	3,018

Buena Vista Lake:

Ducks

Sprig (Dafila acuta tzitzihoa)	200
Mallard (Anas platyrhynchos platyrhynchos)	4
	204

Not all of the birds which recovered from *botulinum* poisoning were banded because bands were not available when some of the birds were released.

A KEY TO THE FISHES OF THE SACRAMENTO-SAN JOAQUIN BASIN[1]

By Garth Murphy
Sacramento Junior College
Sacramento, California

Introduction

This key is designed to aid students who are not professional ichthyologists but who occasionally have need to identify some of the fishes in the Sacramento-San Joaquin drainage basin. Some of the scientific names are somewhat tentative, because much work is still to be done on our California fresh-water fishes, particularly on the genera *Salmo, Hesperoleucus, Rhinichthys* and *Cottus.*

How to Use the Key

This key is based on *alternate characters,* that is, one character is given under 1a and the contrasting character under 1b, the same for 2a and 2b, etc. In some cases there are three alternate characters. *Always* read all the alternate characters before deciding which one your specimen fits. For example, in running down a "Square-tailed Catfish" use characters 1b, 3b, 5a, 6b, 7a, and 8b. If a word or term troubles you, look it up in the glossary or on the diagrams. After identification the fish should be compared with a description of the species. The best descriptions available are to be found in the publications, "The fishes of North and Middle America," by Jordan and Evermann, and "The fishes of the Sacramento-San Joaquin basin, with a study of their distribution and variation," by Cloudsley Rutter. (See list of references.)

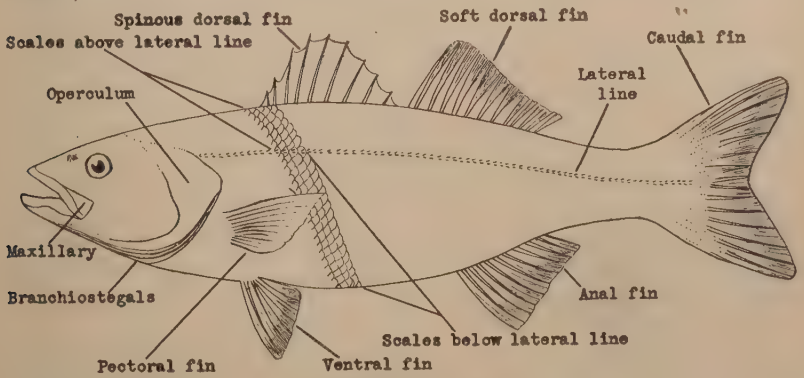

Fig. 46. Diagram of a fish, showing various anatomical characters used in the identification of fishes.

[1] Submitted for publication, December, 1940. The streams tributary to San Francisco Bay are included in the Sacramento-San Joaquin drainage system.

Artificial Key to the Fishes of the Sacramento-San Joaquin Basin [2]

1a. Gill openings 7 in number on each side of the head.

2a. Supra-oral lamina with 3 teeth, the middle one ⅛ to ½ the height of the other two; size large. Pacific Lamprey, *Entosphenus tridentatus*

2b. Supra-oral lamina with a tooth at each end; none or a very small one in the middle; size small, not over 9 inches. Western Brook Lamprey, *Lampetra planeri*

1b. Single gill opening; gills covered by a bony covering.

3a. Body with 5 rows of large bony plates, each with a large keel or spine.

4a. Dorsal rays 44 to 48; anal rays 28 to 30. White Sturgeon, *Acipenser transmontanus*

4b. Dorsal rays 33 to 35; anal rays 22 to 28. Green Sturgeon, *Acipenser acutirostris*

3b. Body without rows of plates as in 3a.

5a. Ventral fins abdominal; the pelvic girdle not connected with the pectoral or shoulder girdle.[3]

6a. Dorsal fin preceded by 3 free spines. Three-spined Stickleback, *Gasterosteus aculeatus*

6b. Dorsal fin not preceded by free spines; all spines present connected by membranes to the dorsal fin.

Fig. 47. Diagram illustrating the three free spines in the stickleback, *Gasterosteus*.

7a. Pectoral fin with one large bony spine; body scaleless.

8a. Caudal fin forked or deeply rounded inward. Fork-tailed Catfish, *Ictalurus catus* *

8b. Caudal fin square or slightly rounded inward. Square-tailed Catfish, *Ameiurus nebulosus* *

7b. Pectoral fin with no spine whatsoever; body with scales.

9a. Adipose fin present.

10a. Dorsal fin with 20 to 24 fin rays. American Grayling, *Thymallus signifer* *

10b. Dorsal fin with less than 15 rays.

11a. Anal fin elongate, 12 to 19 rays (rarely 12, 18, or 19); gill rakers 19 to 40 (rarely 19 or 40) on first arch; branchiostegals 12 to 19; adults with dorsal fin plain or with dark blotches, but without definite spots; mouth blackish in adults; Pacific salmon.

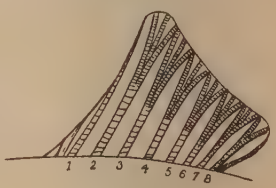

Fig. 48. Diagram illustrating method used in counting dorsal and anal rays. The last ray is often branched at base and is counted as one.

12a. Scales very small, about 170 to 232 oblique rows crossing the lateral line. Pink Salmon, *Oncorhynchus gorbuscha*

12b. Fewer than 160 oblique rows crossing the lateral line, usually 120 to 153.

13a. Scales usually 19 to 26 (range 19 to 31) above, and usually 15 to 24 (range 15 to 27) below the lateral line. Chum Salmon, *Oncorhynchus keta*

13b. Scales usually 25 to 31 (range 23 to 34) above, and usually 23 to 34 (range 19 to 39) below the lateral line.

14a. Anal rays usually 15 to 17; pyloric caeca about 140 to 150; young with parr marks wider than interspaces; the most abundant salmon in the basin by far. King Salmon, *Oncorhynchus tshawytscha*

14b. Anal rays usually 12 to 15 (rarely 12 or 16); pyloric caeca 50 to 83; young with parr marks usually narrower than interspaces. Silver Salmon, *Oncorhynchus kisutch*

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[2] All species which have been introduced into California waters are denoted by an asterisk (*), and those probably introduced from the east side of the Sierra into the Sacramento Basin are indicated by double asterisks (**).

[3] 5b on page 168.

11b. Anal fin short, 9 to 13 rays (rarely 13); gill rakers 20 or fewer on the 1st arch; branchiostegals 10 to 12; dorsal fin with black spots; mouth whitish in adults; trout and chars.

15a. Fewer than 190 scale rows crossing lateral line; species with darkish spots on a lighter background; trout.

16a. Body often profusely spotted; a rosy lateral band usually present; no red or brown spots on sides; the back often a bluish gray; abdomen a silvery white.

Steelhead or Rainbow Trout, *Salmo gairdnerii*

16b. Body usually covered with black spots; no red or brown spots on side; red dash usually in cleft under each side of lower jaw in adults; body slenderer than the rainbow trout.

Black Spotted or Cutthroat Trout, *Salmo henshawi***

16c. Body not so profusely spotted; a few red to brown spots on sides; back covered with brown spots; ground color of back and sides a yellowish or greenish brown; abdomen silvery white.

Brown Trout, *Salmo trutta**

16d. Body with distinct parr marks throughout life in stream forms (lake forms lose parr marks at end of first year); a yellowish orange band on lateral line grading into yellow farther down and finally orange on the abdomen; young lake forms (under 10 in.) not possessing parr marks have instead of typical golden trout color a rather diffuse rosy tinge on a silvery background. Golden Trout, *Salmo agua-bonita*

15b. Over 190 scale rows crossing lateral line; species with light spots on a darker background; usually with red spots on sides; chars.

17a. Back unspotted but strongly mottled with olive and black (the spots run together causing a mottled appearance).

Eastern Brook Trout, *Salvelinus fontinalis**

17b. Back not mottled but with light spots like those on sides of body only paler.

Dolly Varden Trout, *Salvelinus malma spectabilis*

9b. Adipose fin absent.

18a. Ventral scutes present.

Shad, *Alosa sapidissima**

18b. Ventral scutes absent.

19a. Mouth directed downward, excessively protractile, sucker-like with papillose lips.

20a. A notch at corner of the mouth between upper and lower lips; restricted to North Fork of Feather River.

Lahontan Sucker, *Pantosteus lahontan***

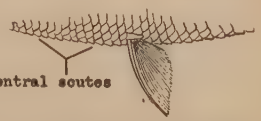

FIG. 49. Diagram illustrating position of ventral scutes in the shad.

20b. No notch at corner of mouth.

21a. Dorsal with 12 to 14 rays.

Sacramento Large-scaled Sucker, *Catostomus occidentalis*

21b. Dorsal with 10 or 11 rays.

22a. Fontanelle almost obliterated in specimens 6 in. long, at most represented by a narrow slit; restricted to Pit River Drainage; not common. Sacramento Small-scaled Sucker, *Catostomus microps*

22b. Fontanelle present throughout life; restricted to the upper Feather River; not common. Tahoe Sucker, *Catostomus tahoensis***

19b. Mouth "normal," not especially directed downward, without papillose lips.

23a. Anal insertion in advance of dorsal insertion.

Mosquito Fish, *Gambusia affinis affinis**

23b. Dorsal insertion much in advance of anal insertion.

24a. Dorsal fin with serrated spine.

Carp, *Cyprinus carpio**

24b. Dorsal without spine.

25a. Over 90 scale rows crossing the lateral line.

Sacramento Blackfish, *Orthodon microlepidotus*

25b. Fewer than 85 scale rows crossing lateral line.

26a. Upper lip with frenum.

Hardhead, *Mylopharodon conocephalus*

26b. Upper lip without frenum.
27a. Upper lobe of caudal fin considerably longer than lower.
Split-tail, *Pogonichthys macrolepidotus*
27b. Caudal fin "normal," the 2 lobes the same length.
28a. Mouth large; maxillary extending to just below anterior edge of the eye.
Sacramento Squawfish, *Ptychocheilus grandis*
28b. Mouth small; maxillary not extending to eye.
29a. Pharyngeal teeth in one row.
30a. Anal rays 11 to 13; body much compressed.
Hitch, *Lavinia exilicauda*
30b. Anal rays 8 or 9; body little compressed.
31a. Gill rakers short and blunt, 8 to 10 on first arch.
32a. Scales in lateral series 47 to 53.
California Roach, *Hesperoleucus symmetricus*
32b. Scales in lateral series 50 to 61, generally 54 to 60.
Venus Roach, *Hesperoleucus venustus*
31b. Gill rakers 13 to 20 on first arch.
Sacramento Channel Minnow, *Siphateles bicolor formosus*

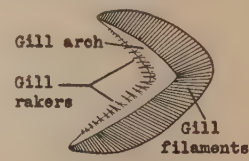

FIG. 50. Diagram of gill arch, showing gill rakers. The count includes the upper and lower halves of the arch. Always count all rudiments.

29b. Pharyngeal teeth in 2 rows.
33a. Barbels often present on posterior angles of the maxillaries; anal rays usually 7 (rarely 8).
California Dace, *Rhinichthys oscula*
33b. No barbels present; anal rays 8 to 11.
34a. Anal rays 8 or 9; caudal peduncle much compressed.
Siboma crassicauda
34b. Anal rays 10 or 11; caudal peduncle not much compressed.
Siboma conformis

5b. Ventral fins thoracic.
35a. Body scaleless and smooth or covered with patches of prickles.
36a. Caudal vertebrae 25 to 29 (usually 25 or 26);[4] lateral line complete.
37a. Posterior nostril tubular; no black spot in the membrane at the posterior third of the first dorsal; soft dorsal with 18 (16 to 20) rays.
Coast Sculpin, *Cottus aleuticus*
37b. Posterior nostril not tubular, normal; a black spot in the posterior third of the first dorsal fin; soft dorsal with 21 (19 to 23) rays; body variously prickly.
Prickly Sculpin, *Cottus asper*
36b. Caudal vertebrae 21 to 23 (usually 22 or 23); lateral line various, either complete or incomplete.
Riffle Sculpin, *Cottus gulosus*
35b. Body with scales.
38a. Dorsal fins separate, the first spinous and the second composed, except for the first ray, entirely of soft rays; body with very narrow longitudinal stripes.
Striped Bass, *Roccus saxatilis**
38b. Dorsal fins united, the spinous dorsal being attached by a membrane to the soft dorsal; body not marked as in 38a.
39a. Anal fin with one or two slender spines.
Yellow Perch, *Perca flavescens**
39b. Anal spines 6 or 7.
40a. Dorsal spines 6 (rarely 5 or 7).
White Crappie, *Pomoxis annularis**
40b. Dorsal spines 7 or 8 (rarely 6 or 9).
Black Crappie, *Pomoxis nigro-maculatus**

[4] The first caudal vertebra is the first vertebra which contains a haemal canal. This is easily recognized by the fact that the blood vessel turns abruptly upward as it passes into the canal. This vertebra is the first counted. The last vertebra counted is modified into the hypural plate.

40c. Dorsal spines 12 or 13.
Sacramento Perch, *Archoplites interruptus*

39c. Anal spines 3.
41a. Dorsal spines 17 (rarely 16 or 18).
Fresh-water Viviparous Perch, *Hysterocarpus traski*

41b. Dorsal spines 9 to 11.
42a. Body sunfish-shaped, the depth about $\frac{1}{2}$ to $\frac{2}{3}$ the standard length; lateral line scales 35 to 55.
43a. Tongue with teeth. Warmouth Bass, *Chaenobryttus gulosus**
43b. Tongue toothless.
44a. Maxillary extending nearly to (rarely a little beyond) the middle of the eye; pectoral fins short and rounded.
Green Sunfish, *Lepomis cyanellus**
44b. Maxillary not nearly reaching to the middle of the eye; pectoral fins elongate and forming an angle of about 30 degrees at the posterior end. Bluegill, *Lepomis macrochirus** [5]

42b. Body bass-shaped, the depth about $\frac{1}{3}$ the length; lateral line scales 58 to 85.
45a. Anal and soft dorsals with no scales on membrane near base.
Large-mouthed Black Bass, *Huro salmoides**
45b. Anal and soft dorsals with scales on membrane near base.
43a. Scales above lateral line 11 to 14; below 19 to 25.
Small-mouthed Black Bass, *Micropterus dolomieu dolomieu**
46b. Scales above lateral line 8 to 10; below 15 to 19.
Spotted Black Bass, *Micropterus punctulatus punctulatus**

Glossary

Explanations of Terms, Counts, and Measurements Used in the Key:

Abdominal. Pertaining to the belly; said of the ventral fins of fishes when inserted considerably behind the pectorals, the pelvic bones to which the ventral fins are attached having no connection with the shoulder girdle.

Adipose fin. A fleshy fin-like projection behind the rayed dorsal fin on the back of some fishes.

Anal fin. The fin on the ventral median line behind the vent; the insertion is spoken of as being the base of the anterior ray of the fin.

Barbel. A fleshy projection about the head; in *Rhinichthys* it is located just anterior to the tip of the maxillary.

Branchiostegals. The bony rays supporting the branchiostegal membranes, under the head of fishes and below the opercular bones behind the lower jaw.

Caudal fin. The tail fin.

Caudal peduncle. The tapering portion of the body behind the last ray of the anal fin.

Compressed. Flattened laterally or side to side.

Dorsal fin. The fin on the back, in front of the adipose fin if that is present; the insertion is spoken of as being the base of the anterior ray of the fin. The dorsal fin is double when there is no membrane at all connecting the spinous portion with the soft rayed portion.

Fontanelle. An unossified space on top of the head, between the parietals, covered with a membrane.

Frenum. A small piece of flesh binding the upper lip to the edge of the jaw.

Gill arch. The bony structure which bears the gills in fishes.

Gill rakers. A series of bony appendages, placed along the anterior edges of the gill arches. They are usually counted on the first arch only.

Insertion. The insertion of a fin is the point at which the anterior ray meets the body.

Lateral line. A series of sensory tubes opening to the exterior on the sides of fishes, and thus forming a more or less distinct line.

[5] Hybrids of the bluegill and green sunfish sometimes occur. These are intermediate in character between these two species.

Maxillary. Outermost or hindmost bone of the upper jaw; the maxillaries often lie above the premaxillaries. To find its relationship to the eye a line should be taken from the posterior tip of the maxillary perpendicular to the axis of the body.

Ovoviviparous. Having the young developed from eggs hatched inside of the body.

Papillose. Covered with papillae, which are small fleshy projections.

Parr marks. The dark vertical bars found on the sides of young trout and salmon.

Pectoral fins. The anterior or uppermost pair of the paired fins.

Pharyngeal teeth. The teeth on the pharyngeal bones, located behind the gills at the mouth of the oesophagus. There is usually a main row of 4 teeth and sometimes a secondary or accessory row of 1 or 2 teeth on each side.

Protractile. Capable of being projected forward.

Rays, soft. Fin rays which are articulated or jointed; sometimes in large adults the first soft ray of a fin will become hard and superficially resemble a spine.

Scales above lateral line. The number of scales counted from a point just anterior to the dorsal insertion obliquely backward to but not including the lateral line.

Scales below lateral line. The number of scales counted on a line obliquely forward from the anterior tip of the pelvic fins, in the bass from just in front of the anal fin, to but not including the lateral line.

Scales, lateral series. The scales are counted as the number of oblique rows along the lateral line. The scales are counted beginning just above the opercular opening to the posterior end of the body, omitting the scales on the base of the caudal fin rays.

Serrated spine. In this key the anterior ray of the dorsal fin of the carp, in which the posterior edge is notched like a saw.

Spines. Fin rays which are unjointed, as the sharp, bony rays found on the basses, sunfishes, etc.

Supra-oral lamina. The anterior tooth-bearing plate in the mouth of lampreys.

Thoracic. Pertaining to the thorax or chest; ventral fins are thoracic when attached immediately below the pectorals.

Ventral fins. The hindmost or lower pair of fins; also called pelvic fins.

Ventral scutes. A series of fine spines along the midventral line of the shad and some other members of the family Clupeidae.

Viviparous. Having the young nourished by means of a placenta and being born alive, as in mammals; often erroneously applied to fishes which are ovoviviparous.

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THE SQUAW CREEK TEST STREAM[1]

A Progress Report Covering Results of the Creel Census on Squaw Creek for the Years 1937-1940, Inclusive

By Allan C. Randle, *U. S. Forest Service*

and

Frederick K. Cramer, *U. S. Fish and Wildlife Service*

During the last four years, 1937-1940, inclusive, a creel census has been conducted on Squaw Creek, a tributary of the Pit River, in the Shasta National Forest in northern California. The purpose of this report is to present the most pertinent findings of the creel census records to date. The results and facts shown are not final in character in that additional records from another season, possibly several, should be obtained before any conclusive statements of a definitive nature can be made.

The creel census was financed by the U. S. Forest Service during the first three years. In 1940, funds were furnished by the U. S. Bureau of Reclamation as well as the U. S. Forest Service to carry on the work. From its inception, the technical phases of the program have been under the direction of the U. S. Fish and Wildlife Service.[2] Officials of the California Division of Fish and Game have cooperated by supplying trout and aiding in marking and planting fish.

Acknowledgments

In region five of the U. S. Forest Service, Mr. Fred P. Cronemiller, Assistant Regional Forester; Mr. Fred Johnson, formerly Range Examiner; Mr. Ivan Sack, Associate Range Examiner; Mr. M. H. Davis, Supervisor Shasta Forest; Mr. Cooper Smith, Associate Range Examiner; Mr. John Gilman, District Ranger, Redding district; and Mr. Richard Willet, Forest Guard, Squaw Creek Guard Station, all deserve much credit for solving, in a highly satisfactory manner, many administrative and practical field problems.

For direction of the creel census work, acknowledgment is made to Dr. Paul R. Needham, Aquatic Biologist, and Dr. Osgood R. Smith, Assistant Aquatic Biologist, U. S. Fish and Wildlife Service.

To Mr. Alan C. Taft, Chief, Bureau of Fish Conservation, California Division of Fish and Game, thanks are extended for his aid in supplying planting records and for furnishing all trout planted in Squaw Creek. Mr. Joseph Wales, District Biologist, California Division of Fish and Game, contributed valuable advice and arranged for the supply of marked trout from the Mt. Shasta State Hatchery.

Finally, to the hundreds of anglers who have fished Squaw Creek the past four seasons, grateful appreciation is expressed for their

[1] Submitted for publication, June, 1941.

[2] In 1937, 1938 and 1939, the work was directed by the U. S. Bureau of Fisheries. In 1940, this Bureau became part of the U. S. Fish and Wildlife Service. As concerns the Squaw Creek work, no change in directing leadership was made in these years.

cooperation in the test stream program. Were it not for their interested attitude toward this work, the creel census could not have been conducted in a satisfactory manner.

Description of Squaw Creek

Squaw Creek is located in northern California, 40 miles northeast of Redding. In its 35-mile course from the headwaters to its mouth

FIG. 51. A typical section of Squaw Creek.

at the Pit River, the creek descends from 4,000 feet elevation to about 1,000 feet in a well-proportioned series of pools and riffles. The width of the stream varies from about 30 to 60 feet. A typical section of Squaw Creek is shown in figure 51.

No water temperature greater than 76° F. was recorded. This temperature was secured at the lower end of the creek about six miles

above its junction with the Pit River. Daily temperatures taken from May 1 to October 31, 1940, at different places along the course of the creek, all fell well within the range of tolerance by trout. Squaw Creek can be considered a typical mountain trout stream in regard to this factor. Daily forenoon water temperatures taken at the Big Tree camp grounds, approximately 18 miles above the mouth, show a range from 60° to 70° F. during the period June 15 to September 1. During this period the water in Squaw Creek reached its highest temperature. The highest temperatures occur in the lower stretches of the creek and it is in this part that the angling intensity is lowest and trout caught per hour of fishing effort is the least.

Good spawning beds occur at the lower end of nearly all of the pools. Consideration of the physical characteristics of the stream and the amount of predation present, together with the food supply in the creek, lead to the conclusion that this stream is no different in these essential respects than most other northern California mountain streams.

Another consideration of prime importance that made this stream desirable as a creel census area was the fact that only a single road led into the stream, thereby making it the only available way to enter or leave. Hence, by staying below the fishermen at all times, a nearly 100 per cent complete census record was obtained.

Fishes Found in Squaw Creek

Representatives of eight genera, comprising nine species in all, have been found in Squaw Creek.

1. Rainbow trout (Salmo gairdnerii)
2. Brown or Loch Leven trout* (Salmo trutta)
3. Eastern brook trout* (Salvelinus fontinalis)
4. Sacramento pike (Ptychocheilus grandis)
5. Hardhead (Mylopharodon conocephalus)
6. Northern roach (Hesperoleucus mitrulus)
7. Dace (Apocope oscula)
8. Perch (Hysterocarpus traski)
9. Bullhead (Cottus gulosus)

Purpose of the Test Stream

The purpose of establishing Squaw Creek as a test stream was to obtain facts which will lead to better management of trout streams.

Answers to questions such as what happens to small trout planted in streams, what can be expected from natural reproduction of trout in a stream, and what are the best methods of securing a high yield of trout, will furnish the most practical and necessary facts on which to base management procedures.

How can the test stream aid in giving answers to these questions? The increase or decrease in production of trout, as measured by returns to the angler, can be compared over a period of years. The effects of greater fishing effort can be determined which may result in more trout being taken or it may not. If the latter is the case, then the number of trout per hour of fishing effort will diminish. If a decrease

* Introduced species.

in the number of trout caught per unit of effort occurs simultaneously with a decrease in the average size of the fish caught, then perhaps overfishing has occurred. By recording the sizes of the fish caught over a period of years, the creel census will produce information on the size and species taken each year and other information.

Since 1938, all trout planted into Squaw Creek have been marked by clipping off one or more of the fins. In order to recognize the fish

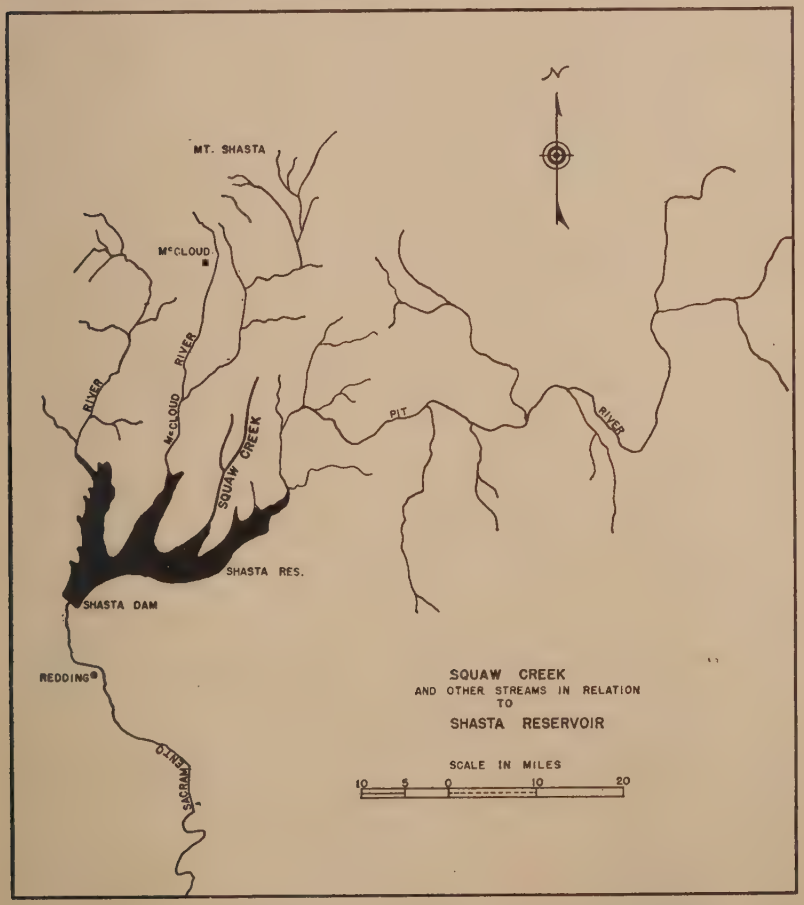

FIG. 52. Map showing Squaw Creek in relation to the Shasta Reservoir. The future level of the reservoir is shown.

when caught later, a different mark was used on each lot planted. Although these fins sometimes regenerate to a partial extent, the planted fish are nearly always recognizable. By comparing the number of marked fish caught with the number planted, the effectiveness of restocking is determined. Here the number of planted trout that finally reach the angler can be determined. Just why such a number is the result, or just why more planted trout are not caught, and just what

happens to trout planted in streams are questions that will require further investigative work to supply the answers. This, however, should not deter us from using facts, once they are known, even though the complex ecological factors that give rise to these truths may remain shrouded in mystery.

After the completion of Shasta Dam and the formation of the reservoir in 1944, an unexcelled opportunity will be present to study the effects of a large reservoir on the fish and the angling value of the tributaries. This will be possible because Squaw Creek will flow directly into the reservoir. The fact that records for four seasons have already been obtained only adds to the desirability that the work be continued. The location of Squaw Creek in relation to Shasta Dam and the reservoir is shown in figure 52.

Returns of Planted Trout to the Fisherman

In any determination of the relative percentage of planted trout that reach the angler's basket, it is necessary, of course, to know the number planted and the number of these that were caught.

TABLE 1

Unmarked Trout Planted and Caught in Squaw Creek

Species	*No. planted*	*Year planted*	*No. caught in each year of the creel census*				*Total catch 1937-40, inc.*
			1937[a]	*1938*	*1939*	*1940*	
Brown trout	130,000	1932-1936	7	20	1	4	32
Eastern brook trout	10,000	1932-1936	0	0	0	12	12
Rainbow trout	40,000[b]	1932 and 1934	2,497	3,238	5,203	4,446	15,384
Total							15,428

[a] From June 10 to October 31 only. Other years covered full six months' fishing season from May 1 to October 31, inclusive. The number of fish caught in 1937 over the entire season would probably have been over 3,600 if the intensity of angling and returns from May 1 to June 10 were the same in 1937 as they were in 1938.

[b] This figure does not include rainbow trout stocked in the Squaw Creek rearing pond. The fish listed above were planted directly into the creek.

Table 1 summarizes trout that were planted and caught in Squaw Creek. Planting records for the years 1932 to 1936 only are used as these are much more accurate than those for earlier years. There is even some question as to the accuracy of the records from 1932 to 1936, but these have been carefully checked and are as accurate as can be obtained. Fish caught by anglers are shown for the years 1937 to 1940, inclusive, during which the creel census was conducted. No record exists of trout caught previous to these years. Only marked rainbow trout were planted after 1936, and the results of these plants in terms of numbers caught by anglers, are presented in table 2.

The rainbow trout listed in table 1 were not marked and since they therefore could not be distinguished from the native rainbow present in the stream, it is impossible to determine their rate of return to anglers.

In the four fishing seasons covered by the creel census, only 32 brown trout[3] and 12 eastern brook trout were taken in spite of the fact that fairly large numbers of these species had been planted.

About 70 per cent of the 32 brown trout taken were less than two years old. Since brown trout have not been planted since 1936, and 78 per cent of the total caught were recorded during the 1938-1940 seasons, inclusive, it follows that the far greater number of brown trout taken were the offspring of the original plants. Yet, these comprised but 0.2 per cent of the 15,428 trout caught.

All of the eastern brook trout recorded were caught in 1940, four years after the last planting date. These were all about 6-inch fish. Hence, they were undoubtedly offspring of previous plants. The number taken was 12, which comprised but 0.08 per cent of the 15,428 trout caught. This species has returned even less to the anglers on the test stream.

TABLE 2

Marked Rainbow Trout Caught by Anglers

Year	*No. planted*	*No. marked trout recovered*
1938	6,200	---
1939	15,800	22
1940	5,040	182
Totals	27,040	204

Table 2 gives the planting and catch record of marked rainbow trout in Squaw Creek from 1938 to 1940, inclusive.

Of the 6,200 planted in the fall of 1938, 1,196 were from the Squaw Creek rearing pond[4] and ran 6.9 per ounce in size. The remainder were from the Mt. Shasta Hatchery, averaging 40 fish per ounce. Those planted in the fall of 1939 totaled 15,800. These averaged 9.0 per ounce and all were from the Mt. Shasta Hatchery except 685 that were planted from the rearing pond at four to the ounce.

The 182 marked rainbow caught in 1940 included only fish from both the 1938 and 1939 plants. However, only 18 of these were trout of the 1938 plant. None of the 5,040 planted in September of 1940 were recovered since they ran only seven per ounce and were too small to enter catches this year.

[3] Also commonly known as Loch Leven trout, but the term "brown" trout is more nearly correct.

[4] The Squaw Creek rearing pond was built for the purpose of determining how effective such a pond might be in "acclimating" trout to a new environment before actually planting them in the creek. By such a practice, it was thought the fish would be larger and stronger when planted and thus have a better chance to survive.

In 1936 and 1937, floods caused the water in the rearing pond to overflow and so the number surviving the period in the rearing pond could not be accurately determined.

In 1938, 5,000 rainbow were planted in the rearing pond on August 8. On October 27, the pond was drained and 1,196 trout recovered, giving a survival of 23.9 per cent. These trout grew from an average of 110 per ounce at planting to an average of 6.9 per ounce at draining.

In 1939, 4,950 rainbow were planted in the rearing pond on July 6. On October 11, the pond was drained and 717 were recovered, giving a survival of 14.5 per cent. These trout averaged 42 to the ounce at planting in the pond. The size at draining was four fish to the ounce. In 1940, the rearing pond was not operated.

Survival of Rainbow Trout

Table 2 shows that 204 marked rainbow found their way into fishermen's baskets out of a total of 22,000 planted. This makes an average of one out of every 108 planted or 0.93[5] per cent. 90.1 per cent of the marked trout caught in 1940 were from the 1939 plant and only 9.9 per cent were from the 1938 plant.

To continue, in 1939 and 1940, the two years when the returns of the marked rainbow could be compiled, wild, naturally spawned rainbow furnished 97.89 per cent of the total rainbow caught and 97.71 per cent of the total trout caught. The wild, naturally spawned rainbow in Squaw Creek have been the mainstay of the fishing during the years that the creel census has been conducted.

These statements are comparable with results obtained in other investigations pertaining to the determination of the return of planted trout. Shetter (1939) in regard to experiments conducted along this type of investigation in Michigan states (pp. 322-324), "in no experiment have the returns (in the form of legal fish) been greater than 1.6 per cent of the total number of fingerlings planted." And likewise he states (loc. cit.), "Although no data are yet available which demonstrate the best size of fingerling trout to plant, or the more advantageous season in which to plant them, all of the experimental evidence thus far presented points toward the inevitable conclusion that the planting of fingerling trout in the waters studied to date have resulted in a negligible return to the fisherman."

Similar low recoveries of planted trout have been reported by Nesbit and Kitson (1937), Needham and Cliff (1938), Hazzard and Shetter (1939), and Surber (1940).

These are the facts, then, on the survival of trout plantings on Squaw Creek. It is recognized that fin-regeneration may have caused some marked fish to be overlooked, not only by the anglers but also by the fish-checkers. The error is not believed to be greater than 10 per cent, however. The difference in the percentage of returns of planted trout would be negligible. Some of the marked trout may very well have moved out of the creel census area downstream to the Pit River. But returns to the fishermen of Squaw Creek, at least, are known. Further study will undoubtedly increase our knowledge as to why the returns are so small.

In September, 1940, 5,040 marked rainbow fingerlings were planted in the headwaters of Squaw Creek. These trout can move downstream as much as 18 miles and still be within the creel census area. The place of capture of these marked trout will be of particular interest in that some valuable information on downstream migration should be obtained.

It might be of value to note that no marked trout have been caught much farther than one mile above the uppermost point at which they were planted. Upstream migration of the planted trout is certainly very slight. A few marked trout were caught a mile below the lowest point of planting, but if they migrated out of the

[5] An accurate check on the return of marked trout should, of course, cover the entire life span of the fish planted and therefore these figures should be considered as tentative pending the additional catch records from later years. It is extremely doubtful, however, that the returns of planted trout will increase sufficiently in later years to appreciably increase the survival rates already determined.

census area or down into the Pit River and did not return, we would have no record of it.

Production of Trout in Squaw Creek

What is the number of trout that Squaw Creek can continue to produce for the fishermen each year without depleting the spawning stock? The existing 4-year record is too short to give a complete answer to this question, but the results and trends, based on the data available, will be given in regard to these queries.

TABLE 3

Shasta National Forest

Results of the 1937, 1938, 1939 and 1940 Creel Census

The following tabulation gives the total number of anglers, angling hours, and average catch for the four seasons.

	1937[a]	1938	1939	1940
Total anglers	140	378	600	688
Total angling hours	1024	2368	3267	2809
Total trout caught	2504	3258	5204	4462
Total rainbow trout	2497	3238	5203	4446
Total Loch Leven trout	7	20	1	4
Total Eastern brook trout	0	0	0	12
Average length of angling effort in hours	7.3	6.3	5.4	4.1
Average catch per angler	17.8	8.6	8.6	6.4
Average catch per hour	2.44	1.38	1.59	1.57
Predominant length class by 2-inch interval	6-7.9	6-7.9	6-7.9	6-7.9

[a] From June 10 to October 31 only. Other years covered full six months' fishing season, May 1 to October 31, inclusive.

As the record for 1937 covers a partial season, the only figures for that year that are comparable with those of the other seasons are the averages presented in table 3.

The greatest numbers of trout were caught during the season of 1939 when 5,204 were taken by 600 fishermen. In 1940, 688 fishermen caught 4,462 trout. Here it can be seen that in 1940, 88 more anglers caught 762 fewer trout. Or, to state it in terms of percentages, in 1940 an increase of fishermen of 14.6 per cent over 1939 caught but 85.74 per cent of the total catch in 1939. Perhaps the limit of production in terms of trout to the fishermen had been reached in 1939.

In 1940, the angler's average catch per day was 6.4 trout; in 1939 and 1938, it was 8.6; and 1937, his average catch was 17.83 trout. Roughly, the average catch of the angler in 1937 was three times greater than in 1940. It should be recognized that normal variation in natural fish populations and fluctuations in the extent and amount of migration have an effect on the angler's catches. The precise magnitude of these influences on the trout fishing in Squaw Creek is not known.

Catches from Tributary Streams

The data in table 3 indicates progressively poorer fishing in Squaw Creek since 1937. The decline in fishing may seem to be proceeding at a rather leisurely rate and not to have reached any alarm-

ing degree. But here we must recognize the inability of these figures to tell the whole story. Actually, the decline of fishing on Squaw Creek is more rapid and has reached a lower point than the figures indicate. In 1939 and 1940, the very rapid increase in the number of anglers has resulted in the total fishing effort being spread over more miles of stream. In these years the anglers, to a much greater extent than in 1937 and 1938, have not only fished the tributaries more extensively but have fished to a far greater degree that portion of Squaw Creek that can be reached only by hiking. The fisherman hiked farther to get better fishing. And, if he fished those waters that were more inaccessible, he did get better fishing as is shown in table 4.

In regard to the increase in the number of anglers, it is interesting to note that in 1940, 54.8 per cent of the fishermen on Squaw Creek were engaged in work relative to the construction of nearby Shasta Dam. It seems that when an area receives a sudden increment in population, the recreational facilities in the forests adjacent to that area receive an added use. Peaks of fishing intensity within the year occur on the opening day of the season, on Memorial Day, the Fourth of July, and on the opening of the deer season in the fall.

TABLE 4

A Comparison of Angling Success Between Remote and Easily Accessible Waters in 1940

Area	*No. of fishermen*	*Trout caught*	*Total hours*	*Trout per angler*	*Average length of angling effort in hours*	*Trout per hour of fishing effort*
Portion of creek paralleled by road	551	2392	2105.5	4.34	3.82	1.13
Tributaries and that portion of Squaw Creek that can be reached only by hiking	137	2070	703.5	15.11	5.13	2.94

Table 4 shows that the part of the creek paralleled by the road has reached a much lower level of production, in terms of both trout per angler and trout per hour of fishing effort, than have the tributaries and the more remote areas of Squaw Creek itself.

In 1937 and 1938, anglers fished the easily accessible waters in a larger proportion, though with a smaller total intensity than in 1939 and 1940. A comparison of the above figure of 1.13 trout per hour in 1940 with the like figure representing approximately the same area in 1937 shows a 54 per cent decrease in the number of trout caught in an hour of fishing effort.[6]

That portion of the creek paralleled by the road received 75 per cent of the total fishing hours but furnished only 51 per cent of the trout in 1940. It most certainly did not offer the best fishing. In terms of trout per hour, it was only 39 per cent as good as the more remote areas; in terms of trout per angler, only 29 per cent as good.

[6] In 1937 the fishing was confined almost entirely to the stream area along the road. The decrease of 54 per cent in the number of trout caught per hour of fishing effort in 1940 is close to the exact figure.

In other words, the total average was definitely sustained by the catches contributed by the tributaries and more remote sections of the main stream.

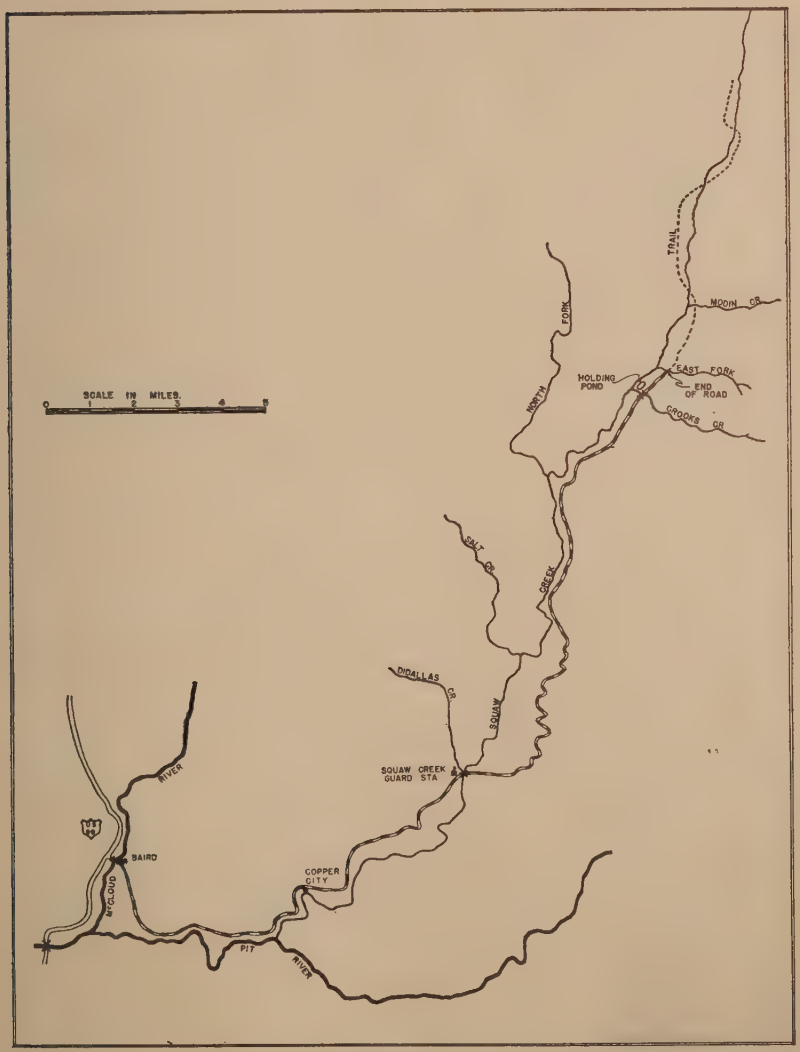

FIG. 53. Map of Squaw Creek showing the U. S. Forest Service Guard Station, junction of Squaw Creek with Pit River, holding ponds, and creel census area, which includes all of the creek above the Guard Station (approximately 27 miles of stream).

A comparison of the size composition of the catches on Squaw Creek for the last four years, however, gives no evidence of depletion. This fact, though, does not nullify the downward trend shown by

the average catch per angler or the trout-per-hour, especially in relation to that portion of the creek paralleled by the road.

TABLE 5

Size Composition of Trout Catches on Squaw Creek, 1937-1940, Inclusive

(Given as percentage of total catch for each year)

Year	4 in. to 5.9 in.	6 in. to 7.9 in.	8 in. to 9.9 in.	10 in. to 11.9 in.	12 in. and over
1937	29.7	48.6	16.2	4.2	1.3
1938	29.55	41.94	20.01	6.18	2.32
1939	31.90	49.40	13.84	3.80	1.06
1940	28.2	48.6	15.7	5.4	2.1

TABLE 6

Trout Catches on Squaw Creek, 1940, by Length Groups

(Given as percentage of total catch)

Area	4 in. to 5.9 in.	6 in. to 7.9 in.	8 in. to 9.9 in.	10 in. to 11.9 in.	12 in. and over
Portion of creek paralleled by road. Larger, warmer waters	23.8	45.5	19.5	7.8	3.4
Tributaries and headwaters of Squaw Creek. Smaller, colder waters	33.4	52.1	11.2	2.7	0.6

Size Composition

Breaking down the 1940 data on size composition of the catch into two divisions, as done in table 6, shows quite distinctly the difference in the size composition of the catches between that portion of the creek paralleled by the road and the more remote, colder and smaller tributary and headwater streams.

The larger percentages of small trout in smaller waters do not mean depletion has occurred. Quite to the contrary, for in these areas the fishing in terms of trout-per-hour was two and one-half times as good as in the larger water paralleled by the road. (See table 4.) The percentages in table 6 merely substantiate the fact that the colder, smaller and better protected headwater streams are inhabited to the larger extent by smaller trout. Over one-third of the trout from these waters were less than six inches long. Eighty-five per cent of them were less than eight inches long. Large fish were more common in the portion of the creek by the road but small fish still supplied most of the fishing. Sixty-nine per cent of them were less than eight inches long. Preliminary observations on scale samples from the entire census area indicate that some 90 per cent of the fish less than eight inches long were in their second year of life, i.e., just past their first "birthday." Fish of this age would not have had an opportunity to spawn and it is quite evident that there is a heavy drain upon the spawning population.

A more complete analysis of the age composition of the Squaw Creek catches, based upon scales from fish of known ages, will be made in the future.

A stream can only produce a certain number of fish. When more are taken away than are annually produced, the returns not only decline in numbers but an encroachment is made on the younger age-groups. So it is on Squaw Creek. Two remedies suggest themselves. One would be to increase production, the other to limit the take. Before an increase in natural production can take place, the number of trout taken out must be limited to permit higher survival to breeding age. Reduction should apply primarily to the younger, smaller fish in order that a greater number of trout may be able to spawn at least once. A size limit or an adjustment of the season might be of some aid in this regard. A reduction in the bag limit would not be effective because of heavy intensity of the angling. The only other alternative is to rely on artificial stocking. This stocking policy, moreover, would have to be different from the present one because, as has been shown, the returns of planted fish to the angler are in the neighborhood of one out of every 108 placed in the creek.

In 1940, the headwaters of Squaw Creek and various tributaries furnished 49 per cent of the trout taken. These are waters that are receiving an ever increasing fishing intensity. If the present level of intensity on the smaller waters increases, or even remains the same, the end result will doubtless see a considerable reduction of breeding stock with consequent lowering of the catch.

Summary

1. A creel census covering four angling seasons from 1937 to 1940, inclusive, has been conducted in Squaw Creek, California.

2. In 1937, 2,504 trout were caught by 140 anglers; in 1938, 3,258 trout were taken by 378 anglers; in 1939, 5,204 trout were caught by 600 anglers; and in 1940, 4,462 trout were taken by 688 anglers. The total recorded catch was 15,428.

3. Wild, naturally spawned rainbow trout have furnished over 97 per cent of the trout taken each year on Squaw Creek.

4. Planted brown trout and eastern brook trout have contributed a negligible return to the anglers in Squaw Creek. Since plantings of these species have failed, they should be discontinued in Squaw Creek.

5. Of marked rainbow trout, only one fish out of every 108 planted reached the anglers' baskets on Squaw Creek.

6. Artificial stocking of trout in Squaw Creek has not been effective under present conditions. Therefore, management procedures on Squaw Creek should take the form of aiding natural propagation in every way possible.

7. Fishing intensity has risen sharply during the four-year period covered. Construction of Shasta Dam nearby played a major part in this use.

8. In the most accessible portion of the creek, along the road, returns to anglers, in terms of trout-per-hour of effort, have decreased approximately 54 per cent.

9. For the whole stream only a small decrease in the catch-per-hour of effort is indicated over the four-year period. Fishermen have gone farther upstream and into the tributaries where increased catches have maintained the success ratio fairly well.

10. Forty-nine per cent of the total 1940 catch was taken in the smaller tributaries. These were caught by 20 per cent of the fishermen. Tributary fishing was 2.6 times as good as the fishing along the road.

11. The catch on Squaw Creek is so heavy that very few mature spawners are left in the stream.

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CREEL COUNTS IN CALIFORNIA [1]

By Brian Curtis

Bureau of Fish Conservation
California Division of Fish and Game

A properly conducted creel count, or creel census, is recognized as an excellent check on the results of stocking policies, stream improvements or other methods of fisheries management.

The ideal count is an intensive one in which every angler on the water under study is interviewed, and every fish caught throughout the season is observed and recorded. Like most ideals, this is seldom attained in practice. Sometimes it is closely approached. Sometimes it is unintentionally but none the less completely missed. And, sometimes it is intentionally discarded, and a new ideal set up in its place: the securing of a significant sample. The effort is then to obtain a count over a short portion of the season which will be of representative or comparative value.

The California Division of Fish and Game has for some time been carrying on creel counts of various kinds. The most intensive one is the June Lake project in Mono County, although even it does not attain the ideal completeness set forth above. Here Elden Vestal, of the Division's biological staff, is carrying out a study of the whole ecological picture. The aims are to find out something about the fish-carrying capacity of a lake of that size and character, and about the survival of hatchery trout and their yield to the fisherman. It is too early to say anything on the first point, but the preliminary figures shed some light on the second.

June Lake, lying at an elevation of 7,600 feet in the Mono Lake drainage, is 310 acres in area. Planted years ago with steelhead it once produced famous catches of this species. Fishing later declined and is now being rehabilitated with rainbow trout from nearby Hot Creek Hatchery. The lake has no spawning streams, and preliminary examinations indicate that the efforts of the rainbow to spawn along the gravelly shore yield no results. It is therefore considered safe to assume that all rainbow in the lake are from hatchery plants. It should be emphasized that the following figures are definitely of a preliminary nature.

Table 1

June Lake Records

	1939	*1940*
Recorded catch of rainbow trout	16,383	18,964
Number of anglers recorded	4,620	6,690
Average catch per angler	3.5	2.8
Average catch per angler per hour	0.7	0.7
Estimated total catch	26,000	----
Average weight of trout recorded	0.44 lbs.	----

The average catch per hour may appear low to the uninitiated, but for comparison, the State of Michigan reports the average catch there

[1] Submitted for publication, June, 1941.

at just about 0.5 trout per angler-hour. And, it must be noted that the average weight of June Lake trout is 0.44 lb., which, by the estimate of 26,000 total of trout caught, means that fishermen took over 5½ tons of trout out of this 300-acre lake in one year.

Yield to the anglers from the fish planted is shown by the following figures:

Marked fish planted in June Lake, 1939: 30,000 rainbow, 3 to 4 inches long	
Marked fish of 1939 plant reported caught in 1939	3,139
Marked fish of 1939 plant reported caught in 1940	2,173
Total caught	5,312
Percentage return to anglers from trout planted	18%

Note that this does not include 1939 fish still surviving uncaught in the lake, nor those fish which survived a few months or a year or more and then died a natural death. More important, it excludes the by no means inconsiderable proportion of the marked fish caught which were not recorded, those caught by cabin owners or elusive shore fishermen. Entirely aside from all of these, it shows a return to the angler of 18 per cent of the trout planted.

Somewhat similar in character is a creel count being carried on at Frog Lake, a 30-acre body of water at 8,000 feet elevation in Nevada County near Truckee. This lake is being planted with rainbow, eastern brook and Loch Leven trout and the objective is to discover the species and number of trout to plant in lakes of this character, which are numerous throughout the Sierra. The count is being carried on through the courtesy of Mr. Felix Smith, owner of the lake, whose family and employees are keeping the records on a voluntary basis and doing a very helpful piece of work. Under such circumstances it can not be expected that a complete record will be made, but results of value can none the less be obtained, as shown in table 2.

Table 2

Creel Counts on Frog Lake, Nevada County

(Voluntarily carried on through the courtesy of Mr. Felix Smith.)

	1938	*1939*	*1940*
Total number of reporting anglers	53	286	271
Total reported catch	288	782	712
Average catch per angler per day	5.4	2.7	2.5
Average catch per angler per hour	0.93	0.81	0.58
Average length all trout	9.8 in.	11.4 in.	10.2 in.

The progressive diminution in the average catch per angler per hour, while not yet by itself conclusive, suggests a possible deterioration in the fishery. The experimental allotment of 15,000 trout per year will, therefore, be increased in 1941.

To turn from the intensive census to the sample creel count, the Truckee River offers the example of longest standing. Counts were originally started here in 1933 to determine the relative proportions of rainbow and Loch Leven trout and the extent to which marked rainbow planted in one spot distributed themselves throughout the river. Such objectives are appropriate for the sample count. At present the principal objective is the comparison of the catch from year to year, and as no attempt is made to obtain the total output of the water, it is the catch per angler or per hour that is significant.

Counts have been made on the opening day of the season, May 1. Table 3 shows the results for the past four years.

Table 3

Sample Creel Counts made on the Truckee River on May 1 between Truckee and the State Line

	1938	*1939*	*1940*	*1941*
Number of anglers checked	84	62	88	78
Number of rainbow caught	34	90	125	111
Number of Loch Leven caught	22	34	34	29
Total of trout caught	56	124	159	165*
Per cent rainbow	61%	72.5%	78.6%	79.3%
Per cent Loch Leven	39%	27.5%	21.4%	20.7%
Average length all trout	12.6 in.	9.7 in.	11 in.	10.6 in.
Average catch per man	0.7	2.0	1.8	2.1
Average catch per hour, trout per man	0.21	0.58	0.52	0.75

* 1941 total of trout includes 25 not identified as to species.

Obviously, counts made on the opening day are not representative of the whole season. On the Truckee, opening day fishing is almost entirely with bait, whereas later in the season many limits are taken on the fly. Also, the lower water which comes later means that more people can catch more fish.

Further, opening day counts are not strictly comparable from year to year due to different weather and water conditions in different years. 1938 was an outstanding example: following an abnormally heavy winter, the season was very retarded, and the opening day catch was, as can be seen, very low. On the whole, however, such counts can be expected to indicate a trend, and the figures for the last three years suggest that the Truckee River fishery is at least holding its own.

It is of interest that the Truckee River in so far as fishery management is concerned is divided into two parts. Below Donner Creek it is stocked only with rainbow, whereas above that creek all the way up to the Lake Tahoe dam it is stocked with Loch Leven only. Counts of a less formal nature made above the Donner Creek junction have shown the catch there to average over 75 per cent Loch Leven, whereas below, as shown in table 3, the Loch Leven now form barely 20 per cent of the catch. It would appear, therefore, that the original decision to divide the stocking in this way was based on a sound appraisal of the natural conditions and their suitability to the two species, since tests elsewhere have shown Loch Leven failing to establish themselves in unfavorable waters. It seems that here each species is well suited to the water in which it is stocked, and that there is very little tendency for either to invade the habitat of the other.

Stevens Creek in Santa Clara County is a contrast to the Truckee. The latter is a mountain river, snowbound for many months of the year and has better fishing later than on the opening day. Stevens Creek, flowing across the Santa Clara Valley to empty into the south end of San Francisco Bay, is rarely touched by snow. In the hills it has been dammed for water conservation purposes, and here it furnishes excellent fishing at the beginning of the season, which dwindles later.

Fishermen are numerous in the early season. Schools let out on the opening day and cars by the hundred are parked along the stream and reservoir. It is impossible with the means available to check anywhere near all of the anglers, and the effort has been to check enough

of them to provide good estimates. The results show great variation from year to year.

In 1939, Fish and Game Warden C. E. Holladay of San Jose, estimated the catch of trout in the creek and reservoir on the opening day to be in the thousands. Later that year the reservoir was drawn practically dry and consequently no fish were stocked. In 1940, the opening day catch was estimated at somewhere in the neighborhood of 100 trout!

Throughout 1940 there was plenty of water. Some 30,000 rainbow and steelhead were planted in the reservoir and creek. Natural spawning took place, and some of the natural spawn of the previous year had undoubtedly survived the drying of the reservoir by staying in the stream above. On May 1, 1941, at 7.30 a.m., 363 parked fishermen's cars were counted, and it is conservatively estimated by Leo Shapovalov of our biological staff that during that day on that 6-mile section of stream and the included reservoir some 1,500 anglers caught some 6,000 trout!

The most recent of our creel counts has just been inaugurated by William A. Dill of our biological staff, with the very valuable help of the Indians of the Tule River Indian Reservation. The census area takes in about 12 miles of the South Fork of the Tule River lying within the Reservation. It is expected to run over a period of years and very little can be said about it yet, but the initial figures, those for May 1 and 2, 1941, shown in table 4, indicate very good fishing, with the average catch at the unusually high figure of 14 trout per angler on the opening day.

Table 4

South Fork Tule River, in the Indian Reservation. Creel Count, May 1 and 2, 1941

Number of anglers checked	104
Number of rainbow recorded	968 (80% of total)
Number of Loch Leven recorded	233 (20% of total)
Total number of trout recorded	1,201
Average catch per angler	11.5 trout
Average catch per angler per hour	2.1 trout
Average catch per angler, May 1 only	14 trout

From these initial figures one interesting fact has already come to light. The stocking in this area has been confined to Loch Leven trout. It has averaged about 30,000 fish per year for the past six years. And yet 80 per cent of the trout caught were rainbows. What are the reasons for this? Their actual determination must await further study, but possible causes are:

1. The Loch Leven have been planted in the lower part of the stream because of doubt of its suitability for rainbow. It may be that conditions here are unfavorable to survival of any species of trout. A survey is projected to study this point, and also the question of natural barriers which are said to confine the planted trout below most of the water fished.

2. There may be such a large number of naturally spawned fish in the stream that planted fish are unable to make a greater showing.

The first item is readily understandable, but the second needs some discussion. To start with an extreme example, if there were no fish in a body of water before it was stocked, every fish caught therefrom

would be a hatchery fish and hatchery fish would make up 100 per cent of the catch. On the other hand, if there were 1,500,000 wild fish in the water and 30,000 hatchery fish were added thereto, they would by the laws of chance appear as only 2 per cent of the catch even if all of them survived; and it is conceivable that their chances of survival are diminished by the presence of a large number of wild fish.

It is possible that the situation in the South Fork of the Tule River is of this nature. If 120,000 rainbow fingerlings were produced there naturally each year, a yearly plant of 30,000 Loch Leven would give a ratio of only 20 per cent in the catch, even if their survival rate were just as high as that of the wild fish. And the number of rainbow recorded in the creel count in the first two days of the season alone could spawn enough eggs to produce a natural crop of more than 120,000 rainbow fingerlings.

The foregoing line of reasoning can be and sometimes is overlooked in a creel-count appraisal of the value of hatchery fish. If the number of fish planted in any water is small in comparison to the number of wild fish already there, their ratio in the catch is bound to be small, no matter how well they survive. And there is a strong possibility that their survival rate is lowered by the presence of a large number of wild fish thoroughly acclimated to the conditions, which both prey upon and compete with them. In other words, the survival rate of hatchery planted fish is very possibly in inverse ratio to the size of the wild fish population in the planted water.

All of which is merely another way of stating a well-known fact: where fishing is naturally good, hatchery fish are not needed. It is where fishing is really poor that the hatchery fish has its chance.

EDITORIALS AND NOTES

TWENTY-FIVE YEARS AGO IN "CALIFORNIA FISH AND GAME"

The July, 1916 issue of "California Fish and Game" was a special deer number; the lead article and many of the short notes related to deer. Frank C. Clarke contributed an interesting discussion of malformed antlers, citing examples and giving causes. Deformities can result either from injury to the antler itself during the growing period or from a wound received by the animal. Reminiscences of old timers in Siskiyou County are related in another article. They tell how the hide hunters killed off the deer in northern California during the 70's and 80's. The short notes refer to deer laws in California and in other states, report on trials with salt licks, and mention a serious deer disease. The State deer kill for 1915 is given as 12,000, about the same as in 1914, with Siskiyou, Monterey and Trinity as the leading counties.

Joseph Dixon contributes an article on the timber wolf in California, in which he asks that specimens be called to his attention. At the time the article was written there was no real proof that wolves ever existed in California, although it was suspected that they had occurred in early days. All cases so far reported had turned out to be mountain coyotes. Comparative descriptions of wolves and coyotes were given to facilitate identification. Since the publication of this article, several authentic cases of the occurrence of wolves in California have been reported and the identity of the animals has been verified. These were all plains wolves rather than timber wolves and had apparently strayed into Lassen and San Bernardino counties from Nevada ("Fur-bearing mammals of California," by Joseph Grinnell, Joseph S. Dixon, and Jean M. Linsdale. Berkeley, University of California Press, 1937. 2 vols.). Further information on the occurrence of wolves in the State is still desirable.

One of the most controversial subjects in the conservation field today is whether or not kelp harvesting is detrimental to fishing. Many fishermen believe that kelp cutting along the southern California coast is harmful and many interested in our bathing beaches claim that cutting causes pieces of kelp to wash ashore to litter the beaches. Harvesting commenced at the time of the first world war when the kelp was used to produce potash, the normal supply of which was cut off by hostilities. More recently kelp has been used in the preparation of balanced diet stock feeds. In an article in the July, 1916 issue of "California Fish and Game," N. B. Scofield reports that studies by government scientists had proved that kelp harvesting is, if anything, beneficial to the kelp beds and would not harm either the fish or the beaches. In spite of these studies and many others made subsequently with the same results, the argument still rages and much bitter feeling exists.

The many short notes in this issue deal with a great variety of subjects relating to wildlife conservation. One of them again takes issue with the reactionary San Francisco newspaper that wished to do away with all game laws; another tells of the use of sea lions in an attempt to destroy carp; another reports the start of a campaign—unsuccessful, alas—to exterminate the English sparrow; others report on the infant salmon trolling fishery at Fort Bragg, which has since reached its zenith and started the too-familiar downhill trail, and the newly expanding Monterey sardine industry which has become so important in recent years. And, there is a long eulogy on the wonderful sport to be had with rod and gun in the southern California of 1916, land of the booster then as now.—*Richard S. Croker, Editor, California Fish and Game.*

A STURGEON IN SOUTHERN CALIFORNIA WATERS

The capture of a green sturgeon (*Acipenser acutirostris*) off the coast of southern California on April 23, 1941, is apparently the first record of this species south of Monterey. The fish, a small one, weighing 7¼ pounds, was taken in a bait net set in 10 fathoms of water between the towns of Huntington Beach and Newport. It was given to the California State Fisheries Laboratory by the boat captain, Howard F. McBain, and has since been deposited in the Natural History Museum of Stanford University.

The species is not to be confused with the better known white sturgeon, *A. transmontanus,* which is found from central California north.—*Phil M. Roedel, California State Fisheries Laboratory, Division of Fish and Game, April 25, 1941.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1940, to March 31, 1941, of the Ninety-second Fiscal Year

Revenue for Fish and Game Preservation Fund:		
License Revenue:		
1941 series—		
Angling	$43,939 50	
Fish tags	968 43	
Game tags	82 32	
Market fisherman	1,020 00	
Fish importers	80 00	
Fish party boat permits	162 00	
Fish breeders	385 00	
Game breeders	1,122 50	
Game management tags	3 66	
Kelp licenses	10 00	
Total 1941 series		$47,773 41
1940 series—		
Angling	$498,737 00	
Hunting	546,603 00	
Commercial hunting club	875 00	
Commercial hunting club operator	305 00	
Trapping	1,929 00	
Fish packers and wholesale shellfish dealers	955 00	
Deer tags	162,487 00	
Fish tags	1,904 00	
Game tags	429 99	
Game management tags	146 35	
Game management	170 00	
Market fisherman	44,310 00	
Fish party boat permits	177 00	
Fish breeder	50 00	
Game breeder	137 50	
Kelp license	20 00	
Total 1940 series		1,259,235 84
1939 series (see November statement)		15,571 50
Total licenses, 92d fiscal year		$1,322,580 75
Other revenue—		
Court fines	$34,305 47	
Deer meat permits	3,141 00	
Fish packers	294,564 35	
Kelp tax	421 34	
Lease of kelp beds	336 40	
Miscellaneous revenue	3,751 36	
Salmon packers tax	29,352 05	
Total other revenue		365,871 97
Total revenue, 92d fiscal year		$1,688,452 72
Prior year, 91st (see November statement)		—3,922 10
Grand total revenue all years, Fish and Game Preservation Fund		$1,684,530 62

STATEMENT OF EXPENDITURES

For the Period July 1, 1940, to March 31, 1941, of the Ninety-second Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Demolition of exposition exhibits	$126 00	$981 08	$3,168 76		$4,275 84
Education and public information	395 16	48 20	261 20	$263 68	968 24
Executive	672 03	210 38	3,841 01		4,723 42
Exhibits			1,274 40		1,274 40
Fish and game magazine		2,281 65			2,281 65
General office	6,032 93	2,282 53	49,280 04	208 22	57,803 72
Library	1,590 00	37 88	133 83	125 63	1,887 34
Property inspection	2,093 41	35 52	150 64		2,279 57
Total Administration	$10,909 53	$5,877 24	$58,109 88	$597 53	$75,494 18
Patrol and Law Enforcement:					
Cannery inspection	$22,492 83	$391 76	$2,273 28		$25,157 87
Executive	12,836 68	341 62	1,593 43	$21 63	14,793 36
General office	5,040 00	582 34	919 79	186 09	6,728 22
Junior patrol	2,750 00	278 63	440 64	450 78	3,920 05
Land patrol	188,152 96	29,115 27	48,298 19	26,910 57	292,476 99
Marine patrol	68,315 48	17,824 20	35,137 06	18,892 71	140,169 45
M. V. *Bluefin* galley		407 14	15 30		422 44
M. V. *N. B. Scofield* galley		205 25	304 86		510 11
Pollution patrol	10,252 00	1,895 05	3,626 21	978 38	16,751 64
Total Patrol and Law Enforcement	$309,839 95	$51,041 26	$92,608 76	$47,440 16	$500,930 13
Marine Fisheries:					
Central Valley water project study	$4,711 50	$735 44	$1,494 15	$43 70	$6,984 79
Executive	3,065 00	32 27	234 20	1 88	3,333 35
Field supervision	2,745 00	194 64	626 44		3,566 08
Fish cannery auditing			3,042 09		3,042 09
General office	8,712 90	381 13	283 39	134 68	9,512 10
Research and statistics	45,881 17	6,848 81	7,431 13	1,296 31	61,457 42
Total Marine Fisheries	$65,115 57	$8,192 29	$13,111 40	$1,476 57	$87,895 83
Fish conservation:					
Biological survey	$8,938 33	$1,501 44	$899 31	$433 82	$11,772 90
Executive	6,458 01	168 30	958 31	621 74	8,206 36
Field supervision	3,220 00	347 07	596 43	10 48	4,173 98
Fish food unallocated		19,389 87	2,578 44		21,968 31
Fish planting	2,171 72	1,173 34	1,055 59	1,337 57	5,738 22
Fish rescue	8,589 83	1,133 55	2,142 21	407 42	12,273 01
General office	5,340 00	749 84	187 35	14 20	6,291 39
Pollution inspection	3,515 66	289 59	613 74	751 02	5,170 01
Statistical	1,745 65	340 80	882 32		2,968 77
Stream improvements			1 68		1 68
Structural maintenance	2,128 55	325 77	895 95		3,350 27
Alpine Hatchery	1,477 59	646 13	148 13	8 17	2,280 02
Arrowhead Lake Egg Collecting Station	5,352 09	1,627 99	890 03	21 53	7,891 64
Basin Creek Hatchery	3,837 09	415 62	348 61	8 59	4,609 91
Bear Lake Egg Collecting Station	160 00				160 00
Benbow Dam Experimental Station	1,523 55	50 75	13 27		1,587 57
Big Creek Hatchery		27 29	—35		26 94
Blue Lakes Egg Collecting Station		30 76			30 76
Bogus Creek Egg Collecting Station	781 28	20 06	125 50	7 90	934 74
Brookdale Hatchery	4,013 80	888 30	587 26	9 97	5,499 33
Burney Creek Hatchery	5,594 18	556 58	247 61		6,398 37
Central Valleys Hatchery	2,486 78	489 97	1,179 30	112 48	4,268 53
Copco Egg Collecting Station	559 35	49 69	88 84		697 88
Experimental Hatchery	810 00	7 21	30 25		847 46
Fall Creek Hatchery	4,813 34	837 59	235 31	578 85	6,465 09
Feather River Hatchery	3,840 00	1,018 52	424 01		5,282 53
Fern Creek Hatchery	1,116 15	317 61	834 62		2,268 38
Fillmore Experimental Station	2,106 56	784 88	576 47	688 00	4,155 91
Forest Home Hatchery	2,254 52	1,584 96	771 09		4,610 57
Fort Seward Hatchery	3,284 81	289 30	121 55	40 40	3,736 06
Heenan Lake Egg Collecting Station		85 17		5 05	90 22
Hot Creek Hatchery	5,010 96	3,571 70	845 94	32 44	9,461 04
Huntington Lake Hatchery	880 32	98 86	244 34		1,223 52
June Lake Egg Collecting Station	320 00				320 00
Kaweah Hatchery	3,705 81	546 82	678 40	6 34	4,937 37
Kern Hatchery	1,262 33	227 05	285 02	1,066 24	2,840 64
King Salmon Experimental Station		18 58	31 04		49 62
Kings River Hatchery	4,454 85	699 66	568 22	12 83	5,735 56
Kirman Lake Egg Collecting Station	393 04	33 70	74 01		500 15
Klamathon Egg Collecting Station	1,068 78	157 92	72 48		1,299 18
Lake Almanor Hatchery	5,194 20	654 83	377 16	86 43	6,312 62

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1940, to March 31, 1941, of the Ninety-second Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Lake Eleanor Egg Collecting Station	$25 16	$23 13		$5 34	$53 63
Little River Egg Collecting Station	343 23	8 05			351 28
Little Walker Lake Egg Collecting Station	255 00				255 00
Mad River Egg Collecting Station	500 00	105 59		8 38	613 97
Madera Hatchery	1,089 20	156 24	$439 87		1,685 31
Mt. Shasta Hatchery	33,352 64	9,886 82	1,939 54	1,225 45	46,404 45
Mt. Tallac Hatchery	1,926 59	1,431 97	208 52		3,567 08
Mt. Whitney Hatchery	11,509 78	1,614 55	1,737 53	38 74	14,900 60
Prairie Creek Hatchery	4,452 67	749 66	633 84	14 81	5,850 98
Rearing Reservoir	1,296 13	1,279 84	554 55	88 55	3,219 07
Rush Creek Egg Collecting Station	347 81				347 81
San Lorenzo Egg Collecting Station		110 84	20 89		131 73
Scott Creek Egg Collecting Station	1,530 00	30 52	112 21	485 28	2,158 01
Sequoia Experimental Station	1,029 02	364 32	544 49	743 54	2,681 37
Shackleford Creek Egg Collecting Station			50 00		50 00
Shasta River Egg Collecting Station	820 33	28 48	10 32	7 15	866 28
Snow Mountain Egg Collecting Station	1,938 45	222 11	64 38		2,224 94
Tahoe Hatchery	6,411 79	1,229 91	721 27		8,362 97
Waddell Creek Station	1,320 00	114 41	76 12		1,510 53
Yosemite Hatchery	4,029 35	861 33	401 67	26 87	5,319 22
Yuba River Hatchery	2,980 00	201 83	124 66		3,306 49
Total Fish Conservation	$183,566 28	$59,576 07	$28,249 30	$8,905 58	$280,297 23
Engineering:					
Engineering	$9,306 61	$1,084 94	$2,472 48	$995 05	$13,859 08
Executive	3,420 00	303 12	832 37		4,555 49
Fish screens	1,009 20	478 18	179 01		1,666 39
General office	1,226 00	30 48	121 37	7 44	1,385 29
Total Engineering	$14,961 81	$1,896 72	$3,605 23	$1,002 49	$21,466 25
Game Conservation:					
Duck rescue	$990 00	$235 94	$790 22	$3 72	$2,019 88
Elk Refuge	1,440 00	267 18	274 36		1,981 54
Executive	7,275 00	581 48	1,401 58	413 96	9,672 02
Game management	8,360 97	1,633 08	2,109 14	1,054 91	13,158 10
General office	2,727 32	32 48	1,079 70	198 31	4,037 81
Grey Lodge Refuge	3,920 00	586 04	132 45	618 63	5,257 12
Imperial Refuge	2,196 13	222 86	179 79		2,598 78
Los Banos Refuge	3,507 35	557 60	442 51	1,657 48	6,164 94
Predatory animal lion hunting	4,874 33	759 65	6,330 03	1,476 60	13,440 61
Predatory animal trapping	25,428 78	6,091 12	4,962 82	3,332 83	39,815 55
Refuge posting		859 85			859 85
Research	5,518 88	877 32	1,741 23	123 70	8,261 13
Statistics	1,456 36	482 35	782 67		2,721 38
Suisun Refuge	2,834 86	446 60	314 96	183 20	3,779 62
Winter feeding and salting of game		121 40			121 40
Total Game Conservation	$70,529 98	$13,754 95	$20,541 46	$9,063 34	$113,889 73
Game Farms:					
Executive	$2,880 00	$72 69	$365 78		$3,318 47
Game bird distribution:					
Los Serranos	1,620 00	353 41	966 64		2,940 05
Yountville	7,669 03	1,594 89	1,958 04		11,221 96
Game management	860 00	292 39	145 60	519 41	1,817 40
General office	836 93	6 93	7 85		851 71
Los Serranos boarding house			31 78		31 78
Los Serranos Game Farm	8,422 52	2,563 97	1,378 69	10 75	12,375 93
Yountville boarding house	731 56	563 77	99 13		1,394 46
Yountville Game Farm	10,063 98	3,351 99	1,260 09	1,697 52	16,373 58
Total Game Farms	$33,084 02	$8,800 04	$6,213 60	$2,227 68	$50,325 34
Licenses:					
Executive	$2,880 00	$116 03	$168 85		$3,164 88
General office	1,222 25	757 96	297 30	$150 90	2,428 41
License distribution	10,492 04	13,636 00	60,101 13	128 82	84,357 99
Total Licenses	$14,594 29	$14,509 99	$60,567 28	$279 72	$89,951 28
Grand total, excluding special support items	$702,601 43	$163,648 56	$283,006 91	$70,993 07	$1,220,249 97

FISH CASES

January, February, March, 1941

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones; undersized and overlimit, no license, closed season	33	$795 00	94½
Angling; no license, closed season, fail to show angling license on demand, alien using citizen's angling license	44	700 00	29½
Bass; Take white sea bass with round haul net, undersized, striped bass, 2 poles in angling for striped bass, no license	36	740 00	
Catfish; closed season, undersized	9	60 00	
Clams; Pismo, overlimit, no angling license, undersized	69	1,282 50	60
Commercial fishing; no license	62	500 00	25
Crabs; possession undersized	2	20 00	
Crappie; closed season	2		
Drag net	5	200 00	
Fishing within 150 feet of the lower side of a dam	1	2 50	
Frogs; possession overlimit and undersized	1	25 00	
Fyke nets; take fish with fyke nets, undersized fyke nets	5	300 00	50
Gill net; in District 2, in District 19-A	11	1,250 00	
Lobsters; possession undersized	7	75 00	
Net; operate in Eel River	3	300 00	
Perch; closed season	1	5 00	
Pollution	29	3,750 00	
Purse seine; illegal use in District 118.5	11	925 00	
Salmon; take other than with hook and line, overlimit, closed area, closed season	10	210 00	
Set lines; in District 12B, in District 12C	8	175 00	71
Spear; possession within 300 feet of a stream, at night	6	90 00	
Steelhead; spear, selling, take with net	10	240 00	100
Sunfish; closed season	1	10 00	
Trap; operate fish trap	1	25 00	
Trout; closed district, closed season, no license	20	480 00	
Totals	387	$12,160 00	430

GAME CASES

January, February, March, 1941

Offense	Number arrests	Fines imposed	Jail sentences (days)
Brant; closed season	2	$25 00	
Cranes; possession sandhill cranes	1		15
Curlew	1	15 00	
Deer; take spike buck, forked horn in District 1¾. Possession two yearling does, closed season, night shooting, killing doe, possession spike buck	35	1,541 50	388
Deer meat; closed season, spotlight	74	1,835 00	610½
Doves; closed season	4	75 00	10
Ducks; shoot from po werboat, overlimit, selling wild ducks, early shooting, closed season	34	1,055 00	
Firearms in refuge	11	660 00	10
Geese; on refuge, closed season	9	315 00	
Hunting; no license, false statement on license, night hunting, on refuge, closed season	24	395 00	15
Hunting club; operate without a license	2	10 00	
Meadlowlarks	1	25 00	
Mudhens; no license, closed season, shoot from highway	4	65 00	
Nongame birds	8	175 00	
Pheasants; closed season, trapping hen pheasant, hen pheasant	24	460 00	195
Pigeons; closed season	11	300 00	
Quail; closed season, overlimit	8	355 00	
Rabbits; no license, jackrabbits, cottontails	18	176 00	14
Robins	4	75 00	
Shoot from powerboat; on refuge, early shooting, from public road	8	125 00	
Shorebirds	2		10
Snares; take game birds with snares	7	37 50	75
Squirrels; possession of grey squirrels	2	10 00	25
Swans; killing and possession	1	50 00	
Trapping; no license, closed season	4	40 00	
Trespass	2		
Waterfowl; closed season, early shooting	6	125 00	
Totals	307	$7,945 00	1,367½

SEIZURES OF FISH AND GAME

January, February, March, 1941

Fish:	
Abalones	108
Abalones, lbs.	60
Abalones, black	288
Abalones, green	10
Abalones, red	69
Assorted fish, lbs.	375
Barracuda, lbs.	665
Bass	29
Bonito, lbs.	100
Catfish, lbs.	350
Clams, lbs.	653
Clams, cockles	852
Clams, Pismo	599
Clams, Washington	34
Devil Fish	2
Lobsters	978
Lobster traps	17
Perch	6
Salmon	24
Sunfish	12
Trout	76
Trout, lbs.	40
Trout, rainbow	4
Trout, steelhead	70
Game:	
Deermeat, lbs.	1,220
Deerskins	3
Dove	1
Ducks	220
Finch	1
Geese	11
Mockingbird	1
Mudhens	6
Muskrat pelts	38
Nongame birds	7
Pheasants	12
Pigeons	19
Quail	17
Rabbits	9
Roadrunners	1
Robins	9
Sandpipers	6
Sea Scoters	1
Squirrel (grey)	1
Willet	1
Woodpecker	1

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1600 8-41 3,800

BUREAU OF ENGINEERING

JOHN SPENCER, Chief—San Francisco
Clarence Elliger, Assistant Hydraulic Engineer—San Francisco
Byron Wittorff, Assistant—Red Bluff
Samuel Kabakov, Civil Engineering Draftsman—San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief—Sacramento
L. O'Leary, Supervising License Agent—Sacramento
R. Nickerson, Supervising License Agent—Los Angeles
Emil Dorig, License Agent—San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Department Accounting Officer—Sacramento

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave)—San Francisco
L. F. CHAPPEL, Chief of Patrol—San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

C. S. Bauder, Inspector in Charge—Sacramento

Northern Division

A. A. Jordan, Captain—Redding
Jos. H. Sanders, Captain—Sacramento
A. H. Willard, Captain—Nevada City
E. O. Wraith, Captain—Susanville
L. E. Mercer, Warden, Butte County—Chico
Chester Ramsey, Warden, Butte County—Oroville
Taylor London, Warden, Colusa County—Colusa
Albert Sears, Warden, El Dorado County—Placerville
E. C. Vail, Warden, Glenn County—Willows
Jack Sawyer, Warden, Lassen County—Westwood
Don Davison, Warden, Modoc County—Alturas
Earl Hiscox, Warden, Nevada County—Nevada City
Wm. La Marr, Warden, Placer County—Tahoe City
Nelson Poole, Warden, Placer County—Auburn
E. J. Johnson, Warden, Plumas County—Quincy
George Shockley, Warden, Plumas County—Portola
H. S. Vary, Warden, Sacramento County—Sacramento
Eugene Durney, Warden, Sacramento County—Sacramento
Earl Caldwell, Warden, Shasta County—Burney
Chas. Love, Warden, Shasta County—Redding
Don Chipman, Warden, Siskiyou County—Dunsmuir
Brice Hammack, Warden, Siskiyou County—Yreka
Lewis Olive, Warden, Siskiyou County—Tule Lake
Fred R. Starr, Warden, Siskiyou County—Dorris
R. E. Tutt, Warden, Sierra County—Downieville
J. E. Hughes, Warden, Solano County—Dixon
A. Granstrom, Warden, Sutter County—Yuba City
R. W. Anderson, Warden, Tehama County—Red Bluff
Harold Erwick, Warden, Tehama County—Corning
C. L. Gourley, Warden, Trinity County—Weaverville
C. O. Fisher, Warden, Yolo County—Woodland
R. A. Tinnin, Warden, Yuba County—Browns Valley

Southern Division

S. R. Gilloon, Captain—Fresno
John O'Connell, Captain—Stockton
R. J. Little, Warden, Amador County—Pine Grove
L. R. Garrett, Warden, Calaveras County—Murphys
F. A. Bullard, Warden, Fresno County—Reedley
Paul Kehrer, Warden, Fresno County—Fresno
Lester Arnold, Warden, Kern County—Bakersfield
C. L. Brown, Warden, Kern County—Kernville
C. S. Donham, Warden, Kern County—Taft
Ray Ellis, Warden, Kings County—Hanford
H. E. Black, Warden, Madera County—Madera
Gilbert T. Davis, Warden, Mariposa County—Mariposa
Hilton Bergstrom, Warden, Merced County—Los Banos
R. Switzer, Warden, Merced County—Merced
R. J. Bullard, Warden, San Joaquin County—Tracy
Wm. Hoppe, Warden, San Joaquin County—Lodi
Geo. Magladry, Warden, Stanislaus County—Modesto
W. I. Long, Warden, Tulare County—Visalia
Roswell Welch, Warden, Tulare County—Porterville
F. F. Johnston, Warden, Tuolumne County—Sonora